



GLASS MANUAL

PITTSBURGH PLATE GLASS COMPANY

THE GEO. BEHM & SONS CO.

How

TO OPERATE THE HEINN B-VELOCITY No. 1 BINDER



1

To Open Binder—Grasp the front and back covers at center of edges and pull both out and lift, separating them to the top.

2

To Close Binder—Put one side in on top, allowing cover to fall back.



3

To Change Sheets—Separate sheet at second place—lift pulling two ends at center along pins, when drawing to the right, sheet is removed.



4

To Get at Further Columns—Turn the front cover and change as far as needed—return the sheets to position for drawing or remove.



5

To Lock Binder—Fasten sheets with Lockfastener. Locking the binder in this way will be useful, especially when used for the study of books, records, etc.

Manufactured by HEINN BINDER CO., CHICAGO, ILL.

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GLASS MANUAL

PITTSBURGH PLATE GLASS COMPANY

1946

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FOREWORD

The credit and appreciation due the editors of the Glass Manual cannot be measured in the simple statement "a job well done."

Theirs was the task of assembling and preparing the vast array of material to be included in the pages of the Manual. Theirs was the responsibility to verify each fact and statement; writing and rewriting to boil down many pages into but a few. To the editors, in short, was given the assignment of creating this work of a scope and magnitude unprecedented in the Glass Industry.

These men, Harry E. Zoll, Clarence W. Condie, and Robert A. Miller, whose joint efforts were responsible for the Glass Manual, can be proud of their work in the knowledge that they have created a living force which may influence the lives and destinies of many.

A handwritten signature in dark ink, reading "Richard B. Tucker". The signature is fluid and cursive, with the first name "Richard" and last name "Tucker" clearly legible. The middle initial "B." is smaller and less distinct.

Vice President

INTRODUCTION

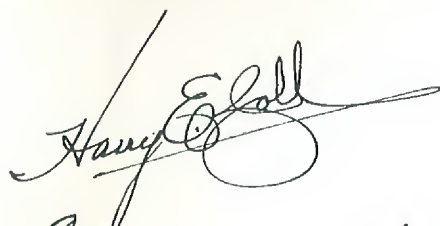
This Glass Manual represents the co-operative effort of many members of the several divisions and subdivisions of the Pittsburgh Plate Glass Company. It is hoped that in this presentation of the subject matter, those who read it may gain a satisfying familiarity with glass and some of the methods by which it is produced in usable form.

The editors have made unstinted use, and frequently verbatim, of data and information derived from many sources. The interest and co-operation of all members of the Pittsburgh Plate Glass Company family who have been approached has been instant and complete and their number is so great that it is impossible to give personal recognition to each and every participant.

The editors wish to express to the editorial committee (Messrs. George L. West, Donald C. Burnham, Powers Pace, Harry R. Kluth, and H. R. Haynes) their deep appreciation of the understanding consideration which they have given to our problems and their willing acceptance of our ideas and suggestions.

Special recognition is due to Dr. S. Frank Cox, Mr. J. S. Gregorius, and Mr. W. G. Koupal of the Pittsburgh Plate Glass Company; Mr. R. D. Humphreys of the Mississippi Glass Company; and Mr. W. J. Aull of the Pressed Prism Plate Glass Company, for their assistance in reading text and their helpful suggestions.

We trust that this book may prove useful in broadening the acquaintance of the members of the organization with the purposes of the Company and particularly, one of its products.


Clarence W. Condie
Robert A. Miller.

SECTION "A"

HISTORICAL DATA

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GLASS . . THE MATERIAL

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PITTSBURGH PLATE GLASS CO. . . THE MAKER

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GLASS . . ITS COMPOSITION



GLASS... THE MATERIAL



RESEARCH



ILLUMINATION



VISION



HEALTH



SHELTER



COMMUNICATION



TRANSPORTATION



FOOD & DRINK

This is the world as we know its man-made objects and benefits. This is the world of glass.

A-1

The History of Glass

Begins with the Creation of the World

In the beginning—darkness encompassed the Earth—and then “there was light”—and Man was created, with eyes to see the light, and the world on which he was to live. Light and sight were the first and most valuable of all the gifts bestowed on Man.

THE WORLD was made to contain elements of matter, from which to compound a unique material that was destined to protect and preserve these gifts by transmitting the light, for without light there could be no sight, and to aid and improve man's vision. Thus in the plan to provide for man's welfare was glass conceived, without peer or parallel, as the servant of all humanity.

We can readily imagine a high state of existence evolving without many of the so-called essential materials to which we have become accustomed, but we cannot remotely imagine a world without glass.

Many who read the printed words on this and succeeding pages would be unable to do so without the aid of glass. Through spectacles, glass has corrected the impairments in our natural vision, improving sight to near perfection. Sight—the most important of man's five senses is responsible for eighty-seven per cent of our human sensations. The fate of mankind would be sorry indeed if deprived of sight and entirely reliant on the four

remaining senses just as God granted them to us.

Dependent on sight are the various means of communication by which we acquire most of our knowledge (correspondence, books, magazines, newspapers, pictures, signs, etc.). The comparative few, not so dependent, such as direct speech, radio, and the telephone have no permanent or enduring value except when recorded; and are susceptible to change or distortion in the process of transmission. Because of this fact there is reasonable doubt of the accuracy of such legendary tales as related by the historian Pliny, who wrote in the first century A.D. of the ancient discovery of glass by a group of Phoenician mariners.

The story describes a scene on a sandy shore of a tidal river in Syria, with the men huddled around a fire and in the process of preparing food. Lumps of natron (soda), carried as ballast in their ship, were used to support the cooking pot. In the dying embers of that fire, which had fused the sand and soda, they discovered the first glass known to man.

Strangely enough, glass is the medium of revelation by which probing scientists are now able to uncover age-old secrets of the world and reconstruct the activities of ancient man.

Thus we learn how in time he began to identify and understand the things he saw, such as the sun in the sky above as the natural source of daylight and reflected at night from the moon. The light was produced by vivid flashes of lightning, erupting volcanoes, and the flaming fire from burning forests. Eventually he succeeded in capturing the flaming fire and with it to light the darkness of the innermost recesses of his shelter, where sunlight did not penetrate. This was a primary function of glass which man had yet to learn how to make and to apply.

To this purpose must Nature have been committed, for during the prehistoric ages, while man was learning to fashion and use stone implements, Nature herself was engaged in the making of glass, fusing the elements of matter in her volcanic fires and spewing them forth in the form of obsidian. In Yellowstone National Park there is today a mass of this material nine miles long, five miles wide, and rising to a height of about 250 feet above the adjoining terrain. It is throughout what we may properly call black glass.

Stone Age man discovered that this natural glass could be broken readily into sharp elongated pieces for arrow and spear heads, and used as cutting implements, knife blades, and razors, but because of its abundance his interest was limited to the purposes it served and not in its reproduction.

Just where, when, or how glass first was made by man is not known, but there is evidence of its being produced by the Neolithic man about 10,000 B.C. There are in existence specimens of glass bearing definite dates which prove that the manufacture of glass slowly emerged from prehistoric obscurity to become a stable Egyptian industry about 1500 B.C.

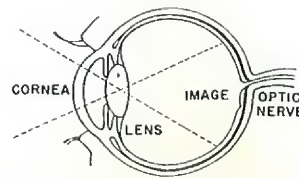
The invention of the blowpipe, credited to a Sidonian artisan, in the third century B.C., made possible quantity production of glass articles in shapes and designs previously impossible to achieve. The utility of glass was now discovered though its real value still remained unknown. The "die was cast" however, for the blowpipe in essentially the same form was to remain for almost two thousand years as the productive instrument with which increasingly skilled artisans explored and expanded the true capabilities of glass. Blocks, cylinders, hollow vessels, vases, urns, jars, bottles, and globes valued largely for their decorative work as well as their utility, became important items of commerce.

Roman glassmakers next learned to "roll out" thin slabs of glass mosaics for wall and pavement decoration—finally adapting such flat pieces to the closing of window areas in their buildings. This dramatic event which occurred about 200 years B.C. had little significance for the people of that period. Yet they had invented a new process of manufacture that was to be the basis of development for plate glass production of the future. But even more important was this first use of glass in windows—despite the fact that their semi-opaque glass admitted only a very feeble light. The idea of using glass in windows—one of the primary purposes which glass was intended to serve—was born.

Well we might wonder how a use so obvious, so commonplace in the world of today, could have so long remained unknown during a period in man's history that contributed so much of practical human philosophy. For it was during this period that the character of man, fashioned through the previous ages and revealing his inner, finer emotions was first given expression in writing and teaching. The contributions of such immortals as Homer, Pericles, Socrates, Plato and Aristotle are long since regarded as literary classics and



SIGHT—most precious of all senses. The eye, most complex of our organs controls or transmits eighty-seven per cent of our sensations. The eye is our personal camera, telescope and bombsight. To evaluate the eye one should ask the man who is blind. Illustrated is the familiar set of lenses that constitute that remarkable little precision machine.



their writings serve as the basis for much of our modern law and culture.

But the people of that age had difficulties to contend with that no longer exist. What they accomplished was not the result of experience. There were no precedents. They were doing everything for the first time, handicapped by lack of material resources. Therefore, progress was slow and it was not until the dawn of the Christian Era that the Romans, as the result of experiments with additional ingredients, succeeded in making the first relatively clear transparent glass.

Only now was glass on the verge of fulfilling its destiny—revealing its unique property of transparency—capable of transmitting light, undiminished—to serve mankind as no other material has or could. That the greatest achievements of man in the entire history of the human race would depend on this quality of transparency in glass was then beyond man's ability to comprehend, and many today are equally unaware of its vital importance. Glass had already given some indication of other unusual properties which man was not yet able to fully appreciate or exploit, but none so momentous as transparency.

Knowledge—health—prosperity—happiness—power—those things which man, during a life-long existence strives to possess, were to thrive and flourish under the influence of this most distinctive characteristic of glass.

The natural affinity between light, sight, and the transparency of glass was apparent. As though unknown forces were conspiring to deprive mankind of its benefits—or at least to delay their becoming effective—over a thousand years passed before man began to realize the potential value of this quality and to apply it. During this period, dynasties and social systems rose and fell. The fate of glass alternately suffered and prospered accordingly. The scenes shifted from Rome



The accident of discovery has been man's ally throughout time. The discovery of man-made glass is one of our precious moments.

to Byzantium—Asia—Germany—France—England. Repeatedly when glass manufacture thrived as a profitable industry it was literally taxed out of existence. It suffered near extinction with the invasion of the barbaric tribes during the fourth and fifth centuries A.D.

Glorious windows built up of a multitude of small pieces of stained glass, appeared in churches in every land during the sixth and seventh centuries. Glass artisans, while carefully guarding their increasing knowledge and skill, migrated to distant shores and re-established their industry so that by the eleventh century every branch of the art was again fully alive. Slowly and laboriously, but surely, the long pent-up secrets of glass



From an ancient frieze it is evident that the Egyptians knew and valued glass; the blowpipe as they knew it is still the common glass forming tool.

Beauty, man-made, is fittingly dedicated to his Master in his Master's house. The breath-taking beauty of a handsome cathedral window never fails to thrill.



Among the little known facts about glass is that it may act as a pipe to conduct light to any desired point. As illustrated, light applied at base of the rod is transmitted through the length of the rod and delivered at its end as an intensified spot.

were being uncovered for the benefit of man.

Roger Bacon, one of the most amazing characters in all history, English philosopher and man of science, born in 1214, was possessed with extraordinary foresight. His active studies and experimental research in optics led him to discover the magnifying properties of convex glass lenses. He conceived and wrote of flying machines, mechanically propelled boats, and is credited with the invention of glass-lensed spectacles. A portrait painted in 1352 shows two mounted glass lenses with handles riveted together in front of the eyes of the subject. Glass—ordained to aid man's vision—was now embarked on a career of service to humanity—unrivalled in the annals of history.

With the invention of printing by Johann Gutenberg in 1446, man's eyes were being subjected to an unaccustomed use which revealed many impairments in vision of which he was not previously conscious. The first printed (Gutenberg) Bible was published about 1460, and printing became an established industry. This stimulated the use of spectacles.

The science of optics flourished and many adapted their talents to this profession. Other phases of the now important glass industry were rapidly developing. Metal-backed mirrors, formed by blowing glass into cylinders which were then slit, flattened out on a stone and polished, were in great demand.

About this time the Grand Council of Venice

virtually imprisoned their glassmaker artisans on the island of Murano, to prevent the French and English from obtaining their trade secrets.

Glass was now aiding man's vision, but its mysterious powers were capable of extending and increasing the scope of that vision. The things we see with the naked eye are necessarily limited to our normal range of vision. Some are unable to perceive objects clearly unless they are near the eyes, others can best distinguish objects at a distance away from the eyes. Glass-lensed spectacles adjusted both these conditions.

Among those who possessed distant vision was Copernicus, 1473-1543, Polish astronomer, whose study of the skies established him as the founder of the theory of astronomy. Also Tycho Brahe—Danish astronomer, since known as the man with telescopic eyes, who in 1575 to 1601, observing the heavens with his naked eyes, succeeded in accurately charting the positions and observable movements of over seven hundred stars.

Remarkable as were these achievements of man's unaided sight, they merely emphasize the awe-inspiring discoveries which the miraculous power of glass made possible.

It was in the year 1590 in Middleburg, Holland, where Zacharias Jansen, glass spectacle maker conducted an establishment. His combination home and workshop was littered alike with samples of glass, ground and unground lenses, spectacle frames, parts, tools, and a brood of children. The latter were constantly underfoot and accustomed to play with the heterogeneous and unclassified glass lenses as casually as modern children toy with marbles. Mynheer Zacharias was in business conference with a friendly, rival spectacle maker, Hans Lippershey, who had brought specimens of glass newly arrived from Vienna, and they, deep in discussion of magnification for reading glasses, paid no heed to the playing children. One of the boys, holding in one hand a concave glass lens to his roguishly squinted eye, proceeded with the other hand to hold at arm's length in direct line of vision a new convex glass lens, filched from Mynheer Lippershey, saying, "Wouldn't it be funny if the mayor had only one eye and had to wear

a pair of funny looking spectacles like this."

Suddenly and without warning, the entire steeple of the church down the street, at which his gaze had been pointed, seemed to leap directly at him. Emitting shrieks of fright, the awe-stricken lad explained to the startled men, who quickly rearranged the dropped lenses and verified the amazing phenomena. They mounted the two glass lenses on a board, finally constructing a more convenient tube, and the first telescope had come into being.

Glass—in this brief moment literally opened man's eyes to an intimate knowledge of his universe. The mind of man now began to concern itself with the possible existence of unknown things, so large and so far away that his unaided vision could not detect them. For years the attention of the great Italian genius, Galileo, was riveted on this subject. In 1609 he constructed an improved refracting telescope, later manufacturing them in quantity. In 1627 Johann Kepler, a German astronomer and mathematician further improved the telescope by using two convex lenses combined with a device for measuring distance. Despite the fact that his normal eyesight was so poor he could not clearly see the stars, his telescope enabled him to chart over one thousand stars, more than previously had been known to exist.

But glass had only begun to demonstrate its true capabilities—now it was to reveal an entirely new world. A world existing since the beginning of time, that surrounds man constantly in every place he looks, yet so small and so close that no

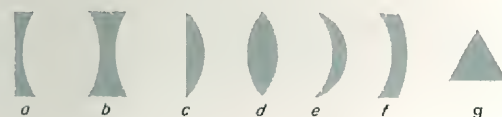
man ever before conceived of its existence.

It was Anthony Van Leeuwenhoek, a Dutch naturalist and expert workman in the art of glass lens making, who in 1660 perfected the single lens, short focus microscope which permitted him to peer into the inner fastnesses of matter, into the kingdom of microbes, of blood corpuscles, and of bacteria. His explorations into this unknown world established him as the father of the science of microscopy. Glass had now made possible the establishment of basic sciences; without glass science would be blind.

Someone has said "Wood never set the world of thought tumbling about our ears and then proceeded to build it up again on an entirely different basis," but glass has done that at least twice—once in the telescope and again in the microscope. Both the astronomer and the microscopist are scientists. Their systematized efforts to gain new knowledge are called research. With the instruments now at their disposal there began a period of unceasing effort to improve and perfect their efficiency which has continued to this present day, with ever increasing momentum.

Meanwhile the making of flat glass sheets was being improved and its use in windows spreading. In England, the development of furnaces employing coal instead of wood for fusing glass, revolutionized the industry and established its importance. Unfortunately, however, both England and France retarded the increasing popularity of glass-enclosed windows by short-sighted and almost prohibitive taxes.

The epoch-making event which gave to glass a



A collection of lenses as generally known—a, plano-concave; b, double concave; c, plano-convex; d, double convex; e, converging concavo-convex; f, diverging concavo-convex; g, prism. Combinations of two or more lenses give us our complex seeing machines of today. Lenses are also combined with prisms (the periscope, bombsight, etc.) for greater effect.

The accidental discovery of the telescope opened a new channel for man's mind. The study of light rays—laws of "bend and focus" become known and established.



To Louis XIV of France we owe the general world-wide acceptance of mirrors. Louis' vanity is reflected today in every home, every car and every woman's handbag.



Grinding and polishing plate glass in the 1700's. The principle of today's method remains the same—the mechanical age has contributed marvels of ingenuity.

Plate glass entering annealing oven in the 1700's.

refinement of character and physical stature not heretofore shown, was the invention of a process to produce polished plate glass.

A method of casting was invented in 1688 by Louis Lucas de Nehou, nephew of a French mirror manufacturer near Cherbourg. Here for the first time was produced large polished plates of flat clear glass of relatively uniform thickness from which it was possible to make very excellent mirrors. These so entranced Louis XIV that he gave particular patronage to the industry. The mirrors in his coaches and in the Hall of Mirrors at Versailles set a fashion that quickly became the rage of all Europe. Its influence extended across the seas to America.

It was here in America that the numerous adolescent properties of glass were eventually to reach their maturity. The roots of knowledge in the art of glassmaking were carefully transplanted from the old world into the first permanent English colony at James Towne, Virginia, in 1608. A nucleus of eight Dutch and Polish glass workers was augmented in 1620 by six Italian artisans, supplemented thereafter at periodic intervals by many others of various nationalities. Eventually, after repeated failures and in spite of many hardships they succeeded, and glassmaking became established as an American industry.

The first important contribution from America was Benjamin Franklin's invention of bifocal glass spectacle lenses in 1760. This improvement represented a real convenience and further aid to man's vision. It was but the forerunner of many astounding developments.

The ingenuity of Enoch Robinson, a carpenter in the employ of the Boston and Sandwich Glass Company, who in 1850 invented a device for rapid production of glass tumblers, is an indication of the resourcefulness of the rapidly developing American character.





Pouring the first "metal" at Creighton, Pennsylvania in 1883. The molten mass of glass is poured onto a cast-iron table—then rolled out by a large cast-iron roll to thickness.

Glass made possible America's most renowned contributions to modern civilization. Glass had long been protecting the flame of man's artificial light in the form of lamp chimneys and globes when in 1879, Thomas A. Edison, in his laboratory at Menlo Park, New Jersey, succeeded in creating the first practical electric light, its fragile filament enclosed in a bubble of glass blown by workmen in his own laboratories.

American enterprise—in developing and commercially exploiting the sensational properties of glass—was creating a glass-enlightened age.

In 1880 the first truly successful Plate Glass enterprise was finally established at Creighton, Pennsylvania, by John B. Ford, John Pitcairn, and other associates. Three years later this business was incorporated in Pennsylvania as the Pittsburgh Plate Glass Company.

In 1884 at St. Louis, Missouri, on the bank of

the Mississippi River, was started the manufacture of rough, ribbed, and figured glass. Later, in 1893, wire glass was first produced by the Mississippi Glass Company.

During the period of twenty years from 1880 to 1900 the United States experienced a great industrial expansion. The building of large railroad systems, manufacturing plants, skyscrapers, and other large industrial and commercial projects, greatly increased the need for flat glass of all kinds.

Man was now demanding of glass the fulfillment of those services it had already proved so capable of rendering. Their buildings needed windows to admit the natural daylight so that gainful occupation, rest and leisure could proceed unhampered by the vagaries of nature's weather. Only glass could adequately serve this purpose. Their buildings needed glass for the display and protection of their wares in the marts of trade and commerce.

All these needs and more did glass supply in constantly accelerating tempo. By 1900 there were one hundred twenty-four flat glass establishments in operation in this country catering to its ever-growing necessities.

In 1903 Michael J. Owens, with the financial support of Edward Libbey, perfected an automatic glass-blowing machine which was the most revolutionary single contribution to the mass production of glass containers in the world's history. Man, the master—in characteristic fashion, required still more of his servant—glass.

The automobile, which had come into being in 1879, was joined by the airplane in 1903. These and other methods of travel subjected man to new and unaccustomed exposure from which he needed protection. In vehicles of transport, on land and sea, under water and in the air, glass forms an invisible barrier against the elements and dangerous missiles from instruments of destruction, preserving his comfort, protecting his life. Protection and preservation were not new services for glass to perform.

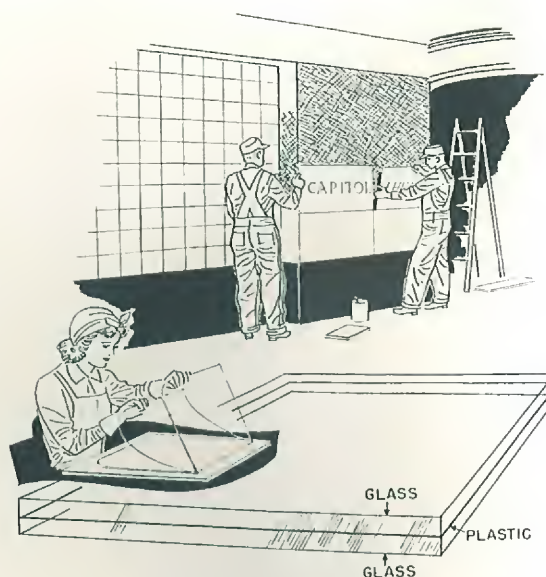
Glass protects the products of man's labor in fields, orchards, laboratories, and workshops, protecting them from theft and corruption, from abuse through handling, and from atmospheric contact. It protects his sight, and health, and life, impartially and with equal proficiency.

Glass became the indispensable servant in man's continual battle for survival against the ravages of disease and infection. Man's health has been guarded, the scourge of many dread diseases abated or eliminated, his span of life increased because of the glass-lensed microscope. During the period 1860 to 1905 the magnifying power of glass-lensed microscopes was steadily increased until it was possible to view an object enlarged two thousand times its actual size. They brought to light the secrets of the origin of disease, the habits and characteristics of bacteria, the atomic structure of all matter: animal, vegetable, or mineral.

Practically every important development in modern science and industry owes its present state of existence to glass.

The huge electronic telescopes which magnify objects twenty-five thousand times their normal size and can further enlarge pictures to one hundred thousand diameters are no exception.

The simple magnifying glasses with their limited power of twenty diameters are not only aids to easy reading but invaluable to such important professions as watchmaking, engraving, die cutting,



Structural glass and safety glass—the most recent applications of mass production glass. Both are firmly established in the life of man—both possess greater possibilities for the future.

carving, and a host of other occupations.

Not yet have mortal eyes beheld all the sights that glass possesses power to reveal.

In 1788 William Herschel, noted English astronomer, constructed what was at that time the largest and most powerful telescope in the world. Its reflecting mirror was forty-eight inches in diameter, its focal length forty feet. With this tremendous instrument he obtained a comprehension of the immensity and wonders of the universe never previously attained.

Remarkable as was this achievement, it fades into insignificance when compared with the mammoth twenty-ton glass mirror disc, two hundred inches in diameter and twenty-six inches thick, recently completed by Corning Glass Works. It is the largest telescope mirror ever conceived by man. The telescope for which it will be the light gathering eye will have a sixty-foot focal length.

Through its glass lenses man will peer one billion light years into space. It will magnify the heavenly bodies ten thousand times and will increase thirty-fold the present known volume of the stellar universe. It will in effect bring the moon within twenty-five miles of the earth. This largest piece of glass ever made, for any purpose, is undoubtedly the most spectacular achievement in the world's history.

The possibilities of its revelations actually stagger the imagination, but who can now value their importance to man, compared with the com-

mon, everyday services that glass lenses are performing, in peace and wartime activities. Binoculars, in reality two telescopes mounted together to serve both eyes simultaneously, scan great distances. The successes in modern warfare are due to the efficiency of glass in periscopes—gunsights—bombsights—rangefinders—crystals. As protective covers for instrument dials and gauges of every type and description does glass function effectively.

Controlled illumination is possible because of glass. Incandescent lights whose glowing glass bulbs are now produced in excess of one billion a year. Fluorescent light of varying intensity and quality in glass tubes. Globes and shades and fixtures in many different sizes, shapes, colors and kinds of glass. Molded into very accurate shapes it becomes an efficient parabolic reflector from which is projected millions of candle power of all-revealing light, flooding the skies and earth alike with its brilliant radiance.

Glass serves to diffuse the light, direct its beams, control its intensity, whether emanating from artificial sources in bulb or tube, the burning flame, or the heavenly bodies.

Our greatest scientific discoveries in chemistry—physics—and physiology—were actually born in glass. In our scientific laboratories where all of the elements of nature are confined and almost constantly subjected to exhaustive research, as man patiently separates or combines them in hopes of making an important discovery, glass is his indispensable aid. Thermometers, test tubes, beakers, retorts, vials, bottles, flasks, hypodermic syringes, all of these are glass. For glass is impervious to practically all chemicals, resistant to

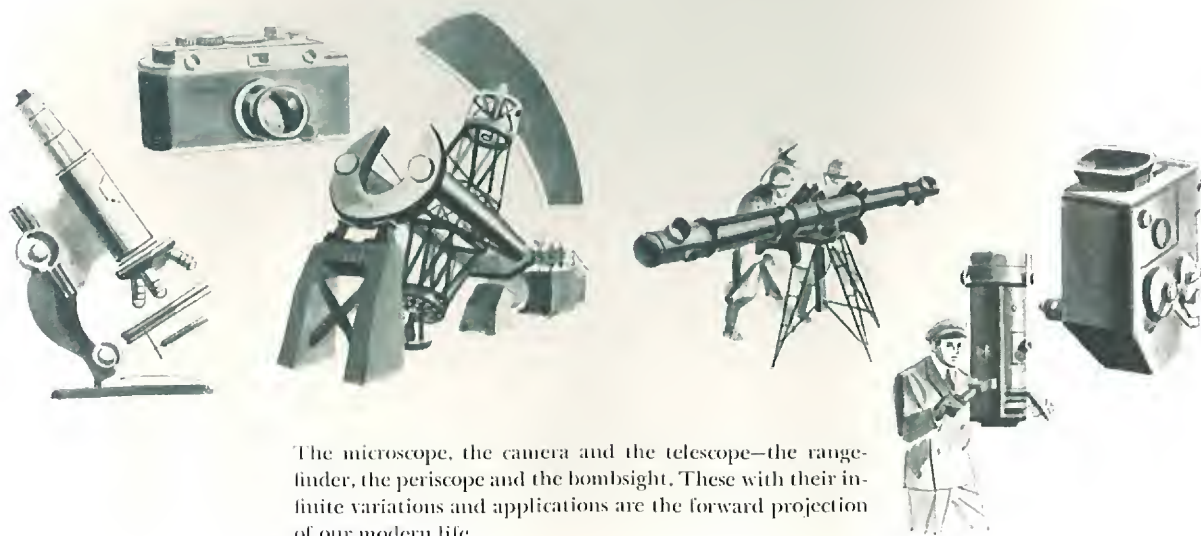
thermal shock as well as physical impact and has the property of transparency which permits full view of the action taking place.

Man's knowledge of invisible solar radiations was spawned in a glass test tube. The X-ray is entirely dependent on glass for its function—in all its applications—curative and exploratory. Violet, ultraviolet and infrared rays are either transmitted or absorbed by various special types of glass. Less commonly known but equally important are the alpha, beta, gamma, cathode, and Roentgen rays, whose existence and benefits would still be unknown without glass.

Nor has glass failed in its mission to contribute to man's pleasure and happiness. The truth of that ancient Chinese proverb "A picture is worth ten thousand words" has long since been verified, for pictures have become the universal language by which men of all countries, civilized or not, arrive at a mutual understanding, regardless of differences in speech. The science of photography depends on glass for both still and moving pictures and again, on glass to project them. Today motion pictures so accurately portray the dramas, tragedies and comedies of human life as it exists all over the world, that they have become our principal source of entertainment and of instruction.

In this modern world of today glass contributes substantially to every phase of human endeavor. Electricity—the telephone—radio and now television depend on glass insulators for their efficacy.

Insulation against sound, heat, and cold—heat radiation—commercial refrigeration—air conditioning—flotation—dehydration—are but a few of the modern industries where glass, in a variety of forms such as double or multiple sheets of flat



The microscope, the camera and the telescope—the rangefinder, the periscope and the bombsight. These with their infinite variations and applications are the forward projection of our modern life.

glass—glass blocks, cellulated glass slabs—fibre glass, lend their invaluable properties.

Not bread alone—but also glass—may truly be termed the staff of life. Our modern civilization enjoys the unparalleled advantages of glass walls, glass doors, glass floors, and glass roofs. Glass furniture and fixtures, glass utensils, vessels and containers. Glass tanks, glass enclosures, glass pipes and glass tubes. Glass thread, glass fabrics, and glass apparel. Glass armor, glass ornaments and other articles too numerous to recount. Glass—either transparent—translucent or opaque—developments of the twentieth century—examples of man's ingenuity and the versatility of the material.

Well we may share the wonder expressed two hundred years ago by Dr. Samuel Johnson, great English lexicographer and critic, who said:

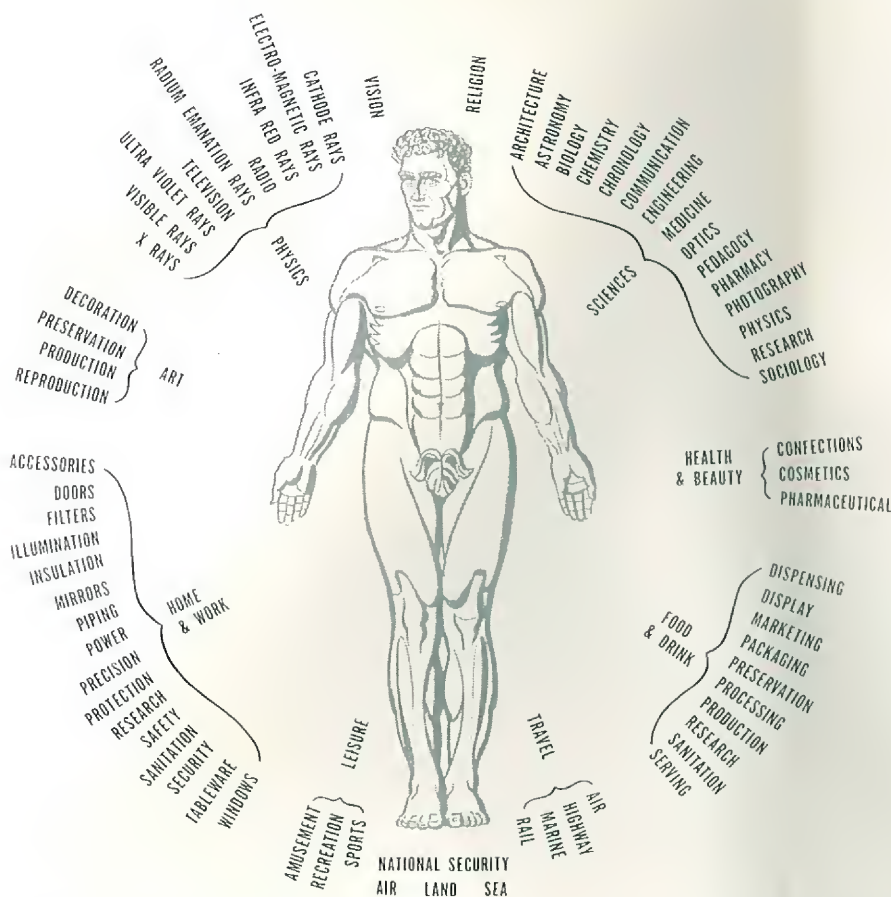
"Who, when he first saw the sand and ashes by casual intenseness of heat melted into a metal-

line form, rugged with excrecences and clouded with impurities, would have imagined that in this shapeless mass lay concealed so many conveniences of life as would in time constitute a great part of the happiness of the world."

The history of glass began with the creation of the world—it has no ending. Ageless—indefatigable—incomparable servant of man and all his possessions, glass will survive for the duration of time. Its future and the future of man because of it, is beyond the power of imagination.

But it is the glass of today that most concerns those favored few who become intimately associated with its production and distribution. Theirs is a privilege and distinction above all others; representing glass to the people whose interests it serves so effectively and to whose welfare it contributes so much.

THIS IS GLASS—THE MATERIAL.



Life, health and sight—Glass and Man. Fundamental to all sensations—omnipresent in daily life, glass insinuates itself into the very being of man. From the cradle to the grave he is surrounded, aided and comforted by glass. From the elements of the world this unique material was com-

pounded to protect and preserve these gifts by transmitting the light, for without light there could be no sight, and to aid sight, and to aid and improve man's vision. Thus in the plan to provide for man's welfare was glass conceived, without peer or parallel, as the servant of all humanity.

I AM GLASS

*I am created of the admixture of Earth's minerals,
formed by the alchemy of time*

*I am born transformed in the blasting heat of fiery
furnace*

*In molten mass I am tediously fashioned by the
hand of cunning Artisan—or fed into the maw
of intricate machine*

*I assume ten thousand hues of all the spectrum—
either transparent, translucent or opaque—upon
my maker's will*

*I can masquerade as ruby—emerald—topaz—moon-
stone; and all the other priceless jewels of man*

*But frivolous banbles are not my aspiration—I
serve ten million purposes in as many different
places, forms and ways*

*My duties are unnumbered—infinite; pay heed to
my utility:*

*I admit the Heavenly light to hovel, palace or cathe-
dral, and yet repel cold winter's howling breath*

*I faithfully project the light that warns great ships
from shoal and concentrate the beams that
guide swift vehicle through storm and gloom of
night to bring the wayfarer safe home*

*I visibly contain my master's food—his drink—and
countless other of his commodities; protecting
them in transport and in the mart and home*

*I form the shell of glowing bulb and tube to dif-
fuse his artificial light—and to disseminate his
advertising*

*I am the walls of his abode, his office and his factory
—and objects of utility and art in each of these*

*I reflect his image—and mark the effects of time
upon his person—sometimes I flatter but more
often am critically severe*

*I correct his impaired sight and thus bestow enjoy-
ment of the printed word—and all of Nature's
beauties roundabout*

*I magnify his minute, unseen enemies and thereby
do I promote his health and happiness*

*I form the gossamer thread from which is fash-
ioned fine raiment—yet too the insulation of his
dwelling*

*I reveal to him the mysteries of his Universe—
carrying his vision to the illimitable reaches of
the outer stars*

*Through me he learned to chart the Firmament—to
plot the orbits of the Planets and predict the
courses of the Comets and Eclipses*

*This knowledge I unfold is but the pledge of vaster
knowledge as—step by step—I lead him to un-
explored, immeasurable spaces*

*For I am older than the Pyramids yet newer than
tomorrow's unborn dawn—withal the marks of
time affect me not—for I am ageless and retain
my lustrous beauty permanently*

*Some of my tasks I have recounted—but this is
only the beginning; for those who make me and
adapt me to their uses, are men of vision—and
together, as time unfolds, we will go far*

*And so—in modesty I proclaim—I am Man's in-
valuable and versatile servant—I AM GLASS.*

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A-2

PITTSBURGH PLATE GLASS COMPANY—THE MAKER



JOHN PITCAIRN 1841-1916

The Hand of Destiny

Guided the Selection of those entrusted with the making of Glass

The plan, wherein glass was conceived as man's servant, could not have provided that its making be left to chance. History has shown that such was not the case for though many were called, few were chosen to succeed in this noble profession. Among the foremost of the chosen few was John Pitcairn—founder of the Pittsburgh Plate Glass Company.

IT WAS in 1880 that Mr. Pitcairn, then an official of the Pennsylvania Railroad became interested in the making of Glass. He listened attentively to Captain John B. Ford, former owner of a steamboat fleet on the Ohio River, who outlined an alluring prospect.

"Grinding sand dredged from the river, limestone quarries, salt beds, soda ash, natural gas to melt the batch, coal for power to turn the machinery, all cheap and conveniently available." Mr. Pitcairn became intrigued and seriously considered the matter.

He was aware that John Ford had already failed twice in similar ventures; first, at New Albany, Indiana, across the Ohio River from Louisville, Kentucky, and later at Jeffersonville, Indiana.

He knew, too, that businessmen and investors looked askance at such undertakings because millions of dollars had already been lost in no less than a dozen unsuccessful attempts, dating back

to 1850 when a company in possession of European patents started plate glass manufacture in Cheshire, Massachusetts.

The reasons for those failures were obvious. The process of plate glassmaking was intricate. All the latest machinery was built abroad; experienced workmen had to be imported. Expert technical supervision was lacking. Foreign competition was keen.

All these difficulties could be overcome with sufficient capital. Plants could be built, and with proper management the making of plate glass could become a successful and profitable American enterprise. There would be increasing need of glass for the residential, industrial, commercial, and institutional buildings of this rapidly expanding young nation.

So John Pitcairn made the fateful decision which launched his industrial career and laid the foundation for one of the most successful



Works No. 1, Creighton, Pa. The first commercially successful plate glass factory in the United States. The site is now occupied by a modern giant plant, and known today as Works No. 1.

manufacturing institutions of the present day.

He invested some two hundred thousand dollars with Captain Ford and associates who organized the New York City Plate Glass Company. Construction of a glass plant already started by Ford at Creighton, Pennsylvania, was then completed, and in 1883 the new factory went into production. Determined that this enterprise should not go the way of its predecessors, Mr. Pitcairn became active in its management.

Plate glass was now being produced on a successful basis for the first time in American history. This original plant was to continue in operation for forty years before being dismantled and replaced with the modern factory in existence today and still known as Works No. 1.

On August 17, 1883, the corporate name was changed to "Pittsburgh Plate Glass Company," as it is known today.

Captain John Ford who by this time had formed the habit of building glass plants now left his interest in the hands of his two sons and journeyed up the Allegheny River to Tarentum, Pennsylvania, where he undertook to build another glass plant. Again it was John Pitcairn whose financial support made the venture possible and enabled it to succeed.

The new plant at Tarentum, when completed,

about 1886, was sold to the Pittsburgh Plate Glass Company for one million dollars in common stock and became Works No. 2, whereupon Captain Ford proceeded up the river to build still another.

This time he selected an unsettled site on the east bank of the Allegheny River about forty miles above Pittsburgh. Here Captain Ford built not only a glass plant, but a town as well.

Ford City, Pennsylvania, is named in honor of this adventurous, pioneer builder of glass plants. Aside from the glass plants which still constitute its principal industry, a feature of the town is its park. Originally planned when the site of the town was mapped in 1887, it contains a statue of John B. Ford, standing, his hands clasped behind him, facing the factory he built.

Hardly had operations begun in 1888 as the Ford City Plate Glass Company, when negotiations to buy the property began. In 1890 the payment of one million five hundred thousand dollars in stocks and bonds purchased Works No. 3.

Almost at once, another factory was built on a site immediately adjoining Works No. 3. This new plant, Works No. 4, was equipped with the newest type of grinding and polishing machinery which was installed by skilled mechanics specially imported for the purpose.

This was a period of great industrial and com-

mercial expansion—instant demands for plate glass exceeded production capacity. Lack of experience, among other factors, was the principal handicap of most of the newer glassmaking organizations that had come into being. The expansion was too rapid and resulted in the panic of 1893 causing the collapse of all but a few manufacturers in the industry. The Pittsburgh Plate Glass Company in 1895 acquired four other plate glass companies with plants located at Charleroi and Duquesne, Pennsylvania; Elwood and Kokomo, Indiana; and at Crystal City, Missouri.

The Company now had nine plants with a combined annual production capacity of twenty million square feet of polished plate glass. Its already extensive resources were rapidly employed to develop the facilities of these new units. There remained only three other companies which continued to operate with a combined capacity of five million square feet annually.

The history of glassmaking at Crystal City dates back to 1871, and is somewhat similar to Ford City in that it also involved the founding of a town. Failing completely in 1876 it was taken over by new interests and was producing some plate glass by 1880 although not on a commercially successful basis.

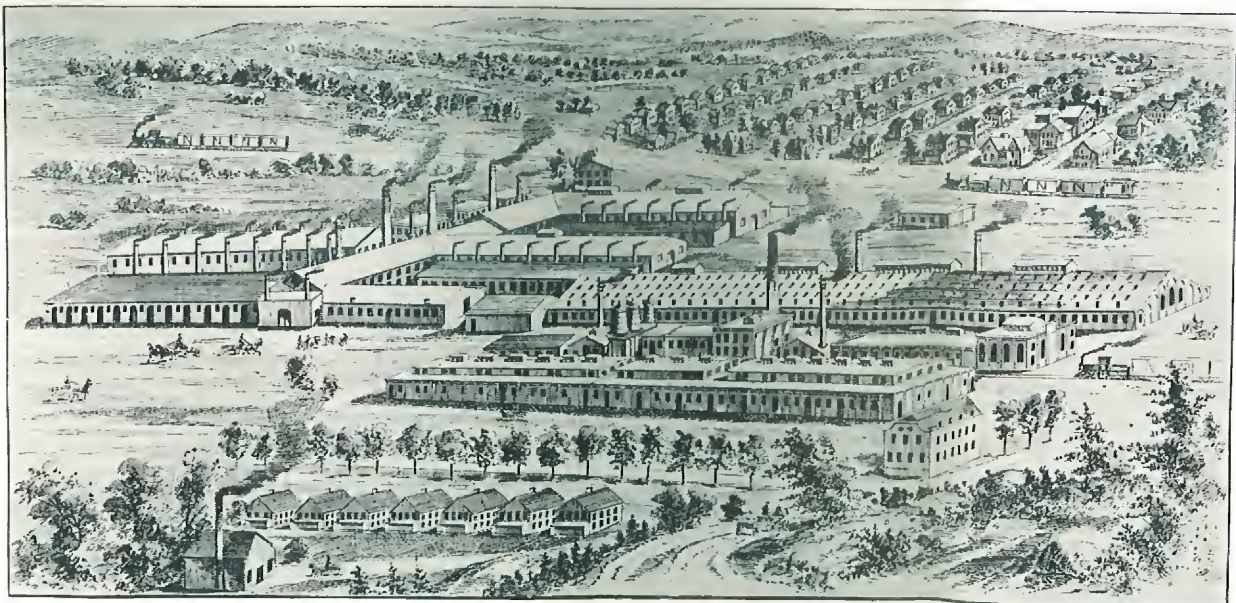
The Pittsburgh Plate Glass Company, as we know it today, had its beginning in 1895.

The Company was then reorganized; the capi-

tal stock increased to ten million dollars; Edward Ford was elected President; Artemus Pitcairn (brother of John), Vice President.



Founder of a community that bears his name, Ford City, Pennsylvania, John B. Ford was a specialist in building glass plants—the Allegheny Valley was his building ground.



Crystal City, Missouri, in 1883, from an old engraving. This plant, too, gave way to modernization and is remembered only as the site of the present Works No. 9.

W. W. HEROY, President. H. CLEVELAND, Treasurer. H. E. SEALEY, Secretary.

THE HEROY COMPANY
No. 927 Arch Street
PHILADELPHIA.

MANUFACTURERS OF
LOOKING-GLASS PLATES
PLAIN AND REVELED

CHANCE'S
FIGURED ROLLED GLASS

INVENTORS OF
PLATE
AND
WINDOW
GLASS

Final Balance
Aug 31, 1896
Heroy Co.

W. W. Heroy	749.07		
bank	162.18		
Stock	175		
Profit & Loss	756.00		
Heroy & Manninger		2142.85	
G. M. Anderson	200		
	5142.85	2142.85	

A billhead of '96. The Heroy Company became Unit No. 1 of the Company's warehouse system.

On the Board of Directors were Messrs. John Pitcairn, Edward and Emery L. Ford (sons of John B.), George W. Crouse, A. U. Howard, A. L. Conger (formerly Diamond Plate Glass Company), and Ethan Allen Hitchcock (formerly Crystal Plate Glass Company).

The Company, which was then operating two coal mines in addition to the nine plate glass factories, moved its general office from the Creighton factory to Pittsburgh, Pennsylvania, where it has since remained.

Brought to light during this significant period were several outstanding personalities, destined for important roles in the development of the Company. With the acquisition of the Diamond Plate Glass Company interests at Kokomo and Elwood, Indiana (the latter plant producing glass refractories), came William L. Clause who was appointed Sales Manager for Pittsburgh Plate Glass Company.

About this time, 1895, Clarence M. Brown was graduated from the University of Pennsylvania with an L.L.B. degree and became associated with Mr. John Pitcairn as an attorney.

A year later Harry S. Wherrett, who started in 1891 with the Diamond Plate Glass Company organization as Mr. Clause's office boy, came to Pittsburgh in a clerical capacity.

Mr. Clause suggested that it would be advantageous for the Company to own and operate distributing warehouses rather than rely entirely on independent wholesale distributing companies for its principal source of business.

Such outlets would insure permanent distribution of Company products, and through sales to contractors and retailers in the building and hardware trades, could be operated profitably.

John Pitcairn thought the idea had merit. The Fords opposed the proposal. They believed it unsound and impractical, predicting financial ruin if adopted. Notwithstanding, it was decided that the Company would adopt Mr. Clause's plan to enter the warehouse-distributing field.

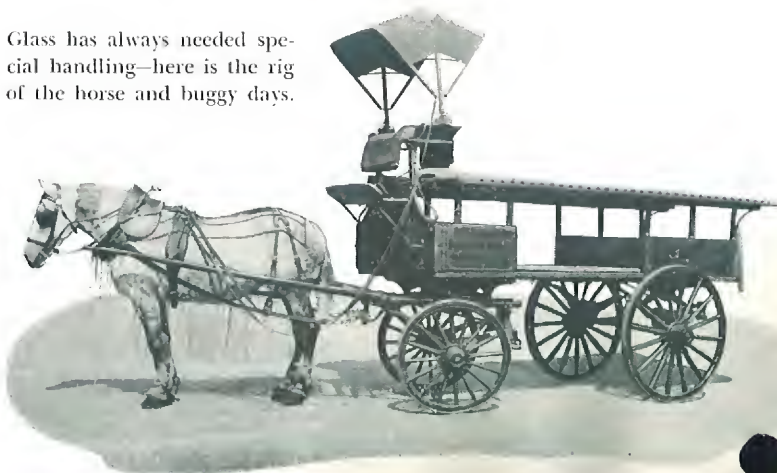
Unable to reconcile themselves to this situation the Fords, essentially glass plant builders, sold their interests in Pittsburgh Plate Glass Company to the Pitcairns, and went off to build another glass plant.

John Pitcairn—now assuming the presidency—proceeded to shape and fashion the corporate character to his own likeness.

He inculcated in the minds and hearts of his associates the virtues of astuteness, prudence, and conservatism, which were his own personal philosophy. Thus he carefully laid the foundation on which would be built the great, independent, and prosperous Pittsburgh Plate Glass Company of the future.

He directed every effort, weighed every decision, evaluated with equal discrimination the personnel of his organization, its operational activities, and its financial transactions.

Glass has always needed special handling—here is the rig of the horse and buggy days.





Charleroi, Pennsylvania, 1898—named for its sister glass city of Belgium was once identified as Works Nos. 6 and 7. Here the army in the first World War conducted research on military optical glass.

He plowed profits back into the business on the principle that only thus could the Company expand in time of prosperity, hold firm in time of depression, and maintain its financial independence. Thus prepared for expansion, the Company acquired seven distributing warehouses.

One of the first was in New York City, located at 424 West Broadway, then called South Fifth Avenue. Here the firm of Heroy and Marrenner, formerly located at 90 and 92 Beekman Street, conducted their business as importers of plate, sheet, and crown window glass.

May 1, 1896, the Heroy and Marrenner firm and the Manhattan Plate Glass Company controlled by Mr. W. W. Heroy became part of the Pittsburgh Plate Glass Company organization.

W. W. Heroy (father of Vice President J. H. Heroy in charge of the Brush Division) became Manager of the New York Warehouse and was later elected to the Board of Directors.

Simultaneously the Company acquired distributing outlets by the purchase of Brown and Haywood Co. of Minneapolis; George F. Kimball Co., Chicago; William Reid, Detroit; F. A. Drew Glass Co., St. Louis; Lovering Bros. & Soule, Boston; and William Glenmy Glass Co., Cincinnati.

Charles W. Brown, affectionately known as "Captain" since his early seafaring days was president of the Brown and Haywood Company when

their business was purchased and was retained as Minneapolis Warehouse manager, until 1898.

With the acquisition of the distributing warehouses, the Company jobbing business had naturally expanded to include in addition to polished plate glass, other items such as window glass, art glass, skylight, and other glass used in the building trades.

Captain Brown's merchandising ability and warehouse experience fitted him to take charge of the Window and Art Glass Departments, for which purpose he was moved to Pittsburgh and appointed Secretary of the Company.



Glass sales in 1889. Glass, Putty and Mixed Paint were sold side by side with Patent Medicines.



Cleaning dross from the siege of a pot furnace. The pot furnace is the basic method for producing glass and has changed but little from the past. The siege is the furnace floor on which the pot rests.

Distributing outlets had increased at the turn of the century by acquisition of branch warehouses of Brown & Haywood Co. at St. Paul and Davenport in 1896; a branch of Heroy & Marrenner at Philadelphia in 1897; establishment of a warehouse at Brooklyn; and by purchase of Barge & Gross at Cleveland in 1900.



Retail outlets have come a long way in a short time.

Reports from this broad field indicated that customers, generally, considered glass and paint companion products.

Mr. Pitcairn and his associates thereupon decided it would be both feasible and desirable to supply the trade through the warehouses with Paints, Varnishes, and Brushes.

In 1900 Pittsburgh Plate Glass Company bought the controlling interest in the Patton Paint Company at Milwaukee, Wisconsin. In 1901 a similar interest was secured in Rennous, Kleinle and Company, Baltimore brush manufacturers. Later the Company purchased the Red Wing Linseed Oil Company; paint factories at Portland, Oregon; Los Angeles, California; and Newark, New Jersey; Ditzler Color Company, Detroit; the Thresher Varnish Company, Dayton; and the Murphy Paint Company Ltd. of Canada. This departure from the original purpose of manufacturing and distributing glass exclusively proved a wise decision and did not detract from the Company's leadership in the glass field.

The broadening interests of the Company re-

quired that it be kept abreast of European developments in glass manufacture so a glass factory located at Courcelles, Belgium, was purchased in 1902. The factory, which was sixty years old, was extended and modernized, and was thereafter successfully operated as a wholly owned subsidiary, the Société Anonyms des Glaees de Courcelles.

Another formative period in the Company history began in 1905 when the founder, John Pitcairn, relinquished the office of President to W. L. Clause, and became Chairman of the Board of Directors.

At the same time Captain Charles W. Brown was elected Vice President and Chairman of the Commercial Department; Clarence M. Brown (no relation to the Captain) was made a director of the Company and two years later became General Counsel; H. S. Wherrett became Manager of Plate Glass Sales. These four men—schooled in the philosophy of the founder—were entrusted with the execution of his policies.

At its Charleroi plant, the Company developed a white opaque flat glass with structural qualities surpassing marble. It was named Carrara, after the white marble of Italy, and took its place as another product of the Pittsburgh Plate Glass Company, of outstanding merit.

Thanks to the resourcefulness and foresight of the founders, the Company factories were never in want of important raw materials. As early as 1899 Company interests had supplied capital to establish the Columbia Chemical Company at Barberton, Ohio. This organization produced heavy chemicals including soda ash, and other glassmaking ingredients, providing a dependable source of supply.

The American flat glass industry was now well established; importations were only fifteen per cent of total domestic consumption. Because of its comparatively low cost the demand for common sheet or window glass was many times greater than for polished plate glass, and about one hundred factories were engaged in its manufacture. Their individual production was limited and unstable. The character and quality of their products varied greatly. The Pittsburgh Plate Glass Company was not engaged in the production of common window glass and could secure its supply only from others.

The jobbing of window glass was an increasingly important item with the Company distributing warehouses, and the conglomeration of brands created a desperate situation. In 1905 the Com-

pany decided to remedy the condition by itself engaging in the manufacture of window glass, and to that end conducted some extensive experiments in a small shop in Allegheny. As a result, window glass became another basic product of the Company when the property of the Chambers Window Glass Company at Mt. Vernon, Ohio, was purchased in 1907. The plant was reconstructed for the production of window glass by the then new process which utilized compressed air to blow cylinders of glass thirty to forty feet long and thirty to forty inches in diameter. This factory became Works No. 11, in the Pittsburgh Plate Glass Company family.

Another window glass factory was added to the Company operations in 1915. The site selected was Clarksburg, West Virginia, center of the state's greatest coal, oil, and gas deposits, historical as the home of Stonewall Jackson.

Glassmaking was now to be organized on a scientific basis. In 1910 officials of the Company decided that the time had arrived to establish a research department to standardize the operations at the various plants, assist in the control of materials and processes, and improve or develop new products. The Research Laboratory was established at Creighton.

The Company was now well organized, well equipped, productive, prosperous, no detail seems to have been overlooked.



Safety glass fabrication is a precise skill. Here a workman is assembling units for the autoclave.

The man who brought it into being—who unstintingly devoted his time, talents, energies, and possessions to the industrial ideal he had espoused—saw it materialize. His mission was consummated. John Pitcairn—Founder—Chairman of the Board of Directors—Pittsburgh Plate Glass Company—died July 22, 1916.

He had built an institution, not upon the shifting sands, but from them producing glass, to whose making he contributed those priceless ingredients, honor and integrity.

With his passing those trained to succeed him carried on. The Board elected Mr. Clause Chairman; Captain Charles W. Brown President. Mr. H. S. Wherrett became Chairman of the Commercial Department. The vacancy on the Board was filled by Raymond Pitcairn, son of the founder.

The Company now owned and operated thirty-three distributing warehouses, strategically located. To meet the requirements of expanding business, its capital stock was increased in 1917 to twenty-five million dollars. There were about seventeen hundred stockholders including many Company employees.

As in most other fields, World War I brought many changes in the glass industry. Most notable, perhaps, was the drastic curtailment of European exports, which vastly increased the demand for American products, particularly in the foreign markets. This led the Company to set up the Export Department to establish markets throughout the world.

Another effect of that war, of special interest to the Company, was the almost complete destruction of the plant at Courcelles, Belgium. Later, the Company's claim for reparations resulting

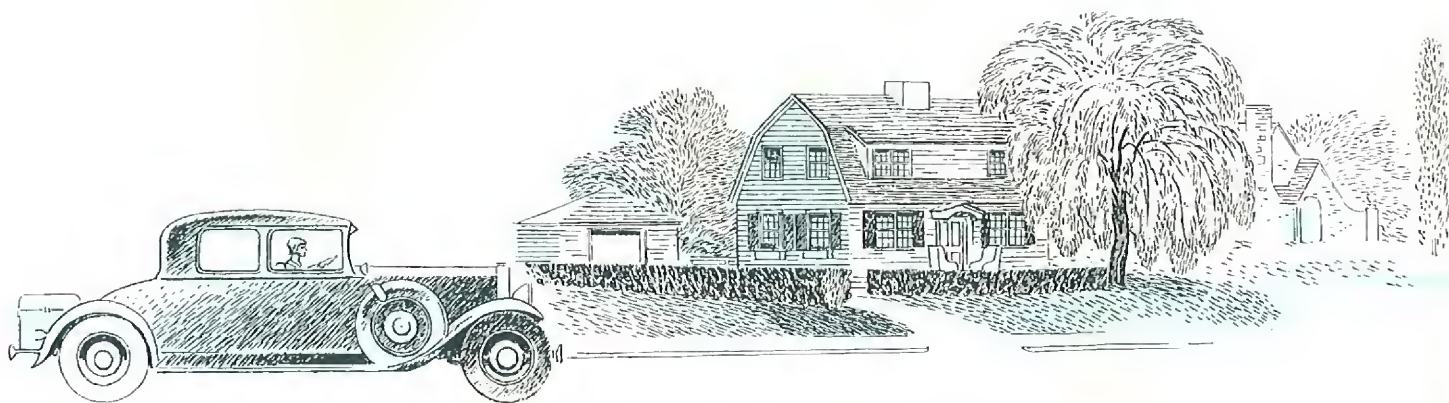
from the looting of the plant by the Germans, was allowed by the International Court of Reparation Claims and paid. During World War II, the plant was not taken over by the German authorities for their own use until January of 1944, although it had been in German occupied territory after May, 1940. The plant was used by the Germans as an aircraft salvage and subassembly plant. It was returned, virtually intact, to the management of its local organization early in September, 1944.

Far more extensive is the domestic distribution of Company products with which the Commercial Department was concerned. Its established policy of entrusting the responsibility of operating warehouses to those of its employees who proved their fitness during years of practical experience encouraged the best efforts of salesmen, office, and factory workers.

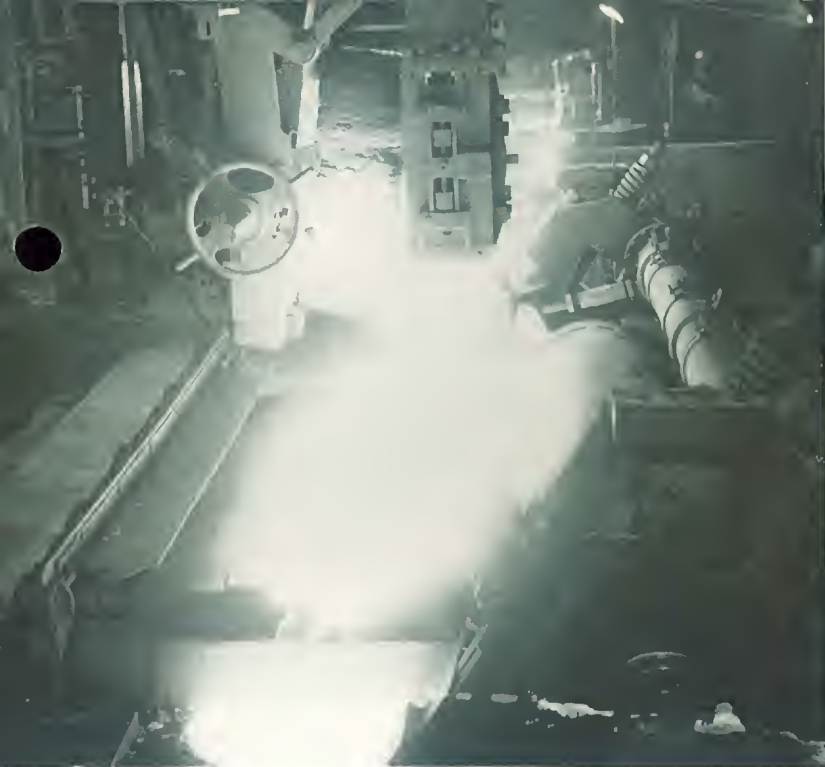
A majority of warehouse managers originally filled minor positions in the warehouses; promotion from the ranks has applied to a large extent in the selection of department heads and officials. This was the personal experience of H. S. Wherrett, who in 1919 was promoted to Vice President.

October 5, 1920, the stockholders unanimously approved the consolidation agreement which brought all subsidiary companies under the one corporate name and sole ownership of the Pittsburgh Plate Glass Company.

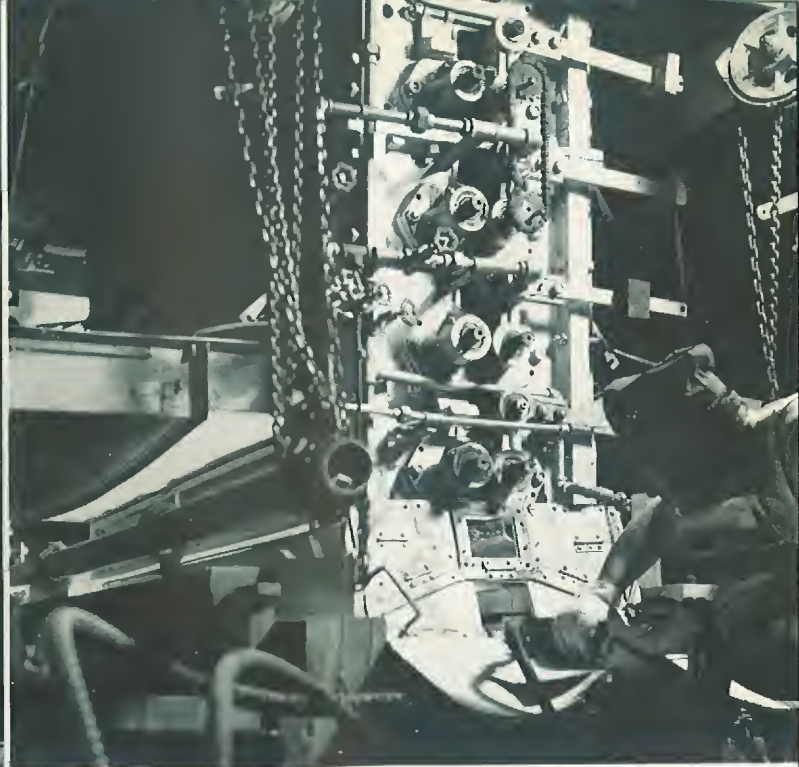
In 1922 Clarence M. Brown, General Counsel, was elected a Vice President. The capital stock of the Company was increased to thirty-seven million five hundred thousand dollars. These actions were timed to cope with the unprecedented demand for Company products during the building boom that followed the postwar depression.



New suburban dwellings with more light and air and a car in every garage became the American way in the 20's. The contribution of glass was taken for granted.



Mechanization was a slow gradual process of the glass industry. Here a teeming crane empties a pot of molten glass onto the casting table, into the forming rolls.



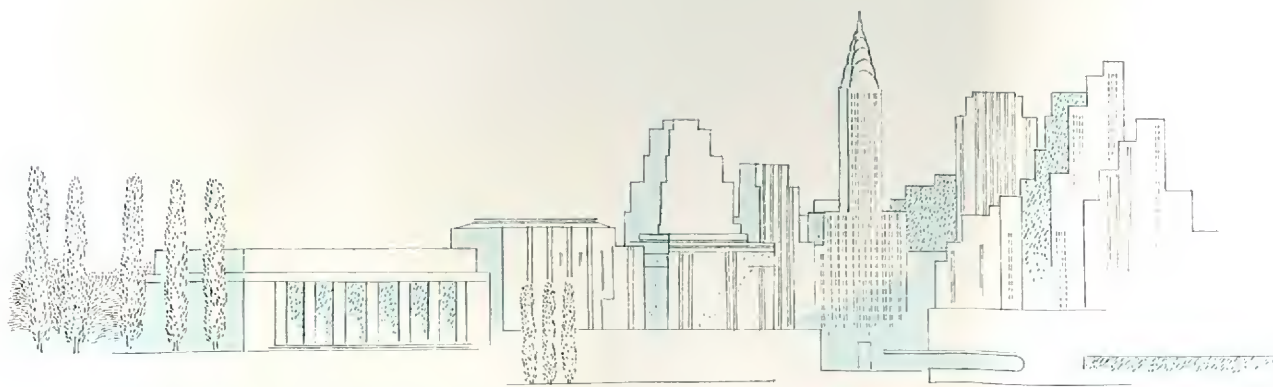
The Pennvernon drawing machine which became the greatest step forward in centuries of window glass manufacture made its debut at Mt. Vernon, Ohio, in 1926.

The closed ear type of automobile was becoming increasingly popular. Thousands of new homes, office and institutional buildings were erected. Many plants and factories which had operated continuously and at full capacity during the war, now had opportunity for repairs or rebuilding. These activities increased greatly the demand for building glass.

The construction trade demanded that warehouse facilities be expanded to include glass installation service. Ever anxious to extend its activities, the Company organized Contract De-

partments in its warehouses. The glazing of buildings became an added and important feature of operations. Store fronts now involved plate glass, metal setting members, and Carrara Glass; interiors were lavishly decorated with plate glass mirrors, Carrara, glass showcases, and fixtures, and many other items.

The production of a continuous ribbon of polished plate glass had long been an elusive dream of glass technologists and engineers. The Research Laboratories at Creighton wrestled with the problem and in the early 1920's developed a



The building boom of the 20's marked the beginning of glass consciousness and found the Company ready and able to care for this tremendous market.

method which has proved eminently successful through the years. A continuous ribbon of plate glass became a reality in 1923 and a new factory, continuing to be known as Works No. 1, was erected on the site of the original plant. A new era in plate glass manufacture had begun with greatly increased production and glass of superior quality. The development of the new process in the new factory gave rise to a new product, with a notably distinctive characteristic pattern of indeterminate design, which was named Tapestry Glass, and which met with instant favor.

In 1923, the capitalization of the Company was increased from thirty-seven million, five hundred thousand dollars to fifty million dollars.

Meanwhile, two different machines had been developed to draw window glass in a continuous flat sheet, but neither could produce glass free from surface blemish, inherent in the process. Company engineers and research workers devoted much time and energy to the perfection of a machine which would overcome this difficulty. The Pittsburgh Plate Glass Company process, producing Pennvernon flat drawn sheet window glass was put into full operation at Works No. 11 at Mt. Vernon, Ohio, in 1926 and in 1927, Works No. 12 at Clarksburg, West Virginia, was similarly equipped. The name "Pennvernon" now distinguished the flat drawn sheet window glass products of the Pittsburgh Plate Glass Company.

During this same period the Company was developing a Safety Glass which would be practical for general use in closed motor car bodies. The rapid evolution of the automobile industry had increased the percentage of closed cars from thirty per cent of the total in 1922 to ninety per cent in 1929 when over five and one-half million cars were built. Safety Glass, involving a sandwich of a sheet of plastic between two lights of glass, where previously one single light of glass was used, became available in 1927. With such tremendous market possibilities the Company proceeded to produce both safety plate-glass and safety sheet-glass products under the trade names Duplate and Duolite. For this purpose a new plant was built at Creighton, Pennsylvania.

Originally owned jointly with E. I. du Pont de Nemours & Co., it was operated as the Pittsburgh Safety Glass Company until 1929 when the name was changed to Duplate Corporation. Two years later the Du Pont interest was purchased, and the Duplate Corporation became a Company unit.

In 1929 the capital stock of the Company

was increased to become sixty-five million dollars.

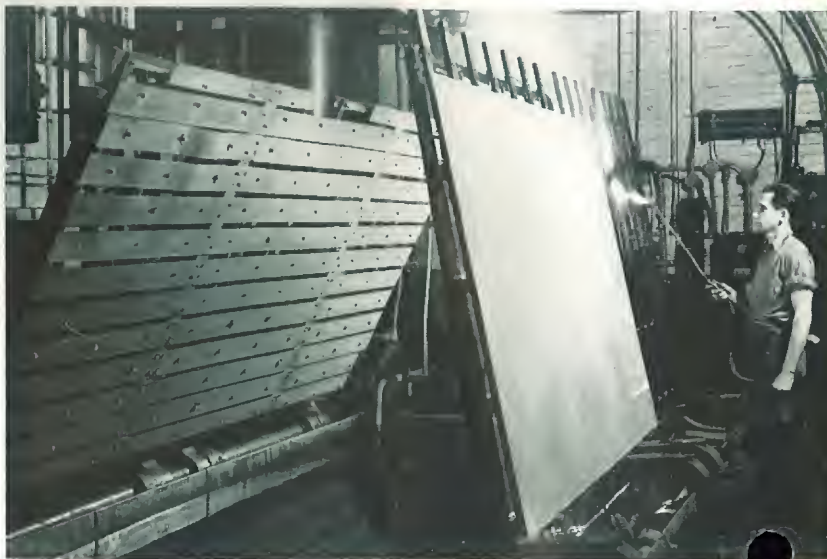
A third Pennvernon window glass plant was erected in 1930 at Henryetta, Oklahoma, for the purpose of serving the rapidly growing consumption in western and southwestern territories and to relieve the excessive demands on the capacity of the eastern plants.

In the midst of this intense activity came the death of Captain Brown — President of the Company 1916-1928. He was the first of the founder's confidants to conclude his mission, and is remem-



Extruding the precision-built Pittco Store Front Metal provides a fundamental structural member of beauty, strength and reliability.

Mirror making is carried out at Works No. 4 at Ford City, Pennsylvania. Here a piece of plate is being cleaned prior to receiving its electrolytic plating.



bered for his considerate attitude toward associates, competitors, and customers alike. He was succeeded in the Presidency by H. S. Wherrett. H. B. Higgins then became a Vice President and Chairman of the Commercial Department.

The strength of the corporate structure was put to the test during the depression of 1930 which it met without faltering.

Neither adverse conditions nor changing markets disturbed the equanimity that has characterized the Company policies since its inception. With calm deliberation it proceeded to intensify its merchandising activities, introduce new products and services, sell the idea of modernization of store fronts to merchants who were eager to attract the attention of the public and a larger share of its patronage.

These operations promoted the use of plate glass, Carrara Glass, and Pennvernion; mirrors, metal store front construction, and paint. The business, thus created, benefited other industries and trades. It was constructive selling and brought to light new markets of great possibilities.

Formerly, workmen were brought from abroad to teach the art of glassmaking; less than fifty years later the situation was reversed. Company success in drawing flat sheets of glass directly from the tank created intense interest in foreign countries. Its representatives started a procession across the water to establish the Pennvernion process of glass manufacture. The procession kept on until it had circled the globe.

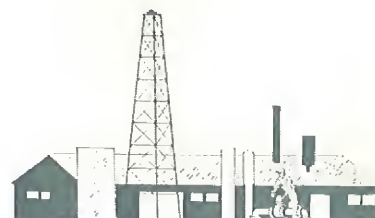
In 1931 death called the second of the founder's contemporaries—W. L. Clause, Chairman of the Board of Directors. He had fathered the idea of a Company-owned warehouse distribution and saw it grow into a mighty organization of seventy-one thriving units. Its continued expansion is a tribute to his memory.

Clarence M. Brown, the most intimate of the founder's associates, was elected to succeed Mr. Clause as Chairman of the Board.

The capital stock of the Company was owned by more than four thousand stockholders including many Company employees. The organization comprised about ten thousand persons including directors, officers, office, warehouse, and factory workers. Its factories produced a variety of glass and paint products, brushes, chemicals, and cement. It owned coal mines and gas wells for fuel, and produced many of its raw materials, and refractories. It owned and operated river steamboats, dredges, barges, and several hundred



The operation of a glass company of the size of "Pittsburgh" includes mining, chemical manufacture and industrial railroading.



Wells produce salt which is later processed into soda. Limestone is converted into lime, and coal is needed in every operation. Hence a coal mine is an integral



part of operation. Gas wells provide fuel for the furnaces that melt the glass and wells are drilled, pumped or abandoned as progress demands.



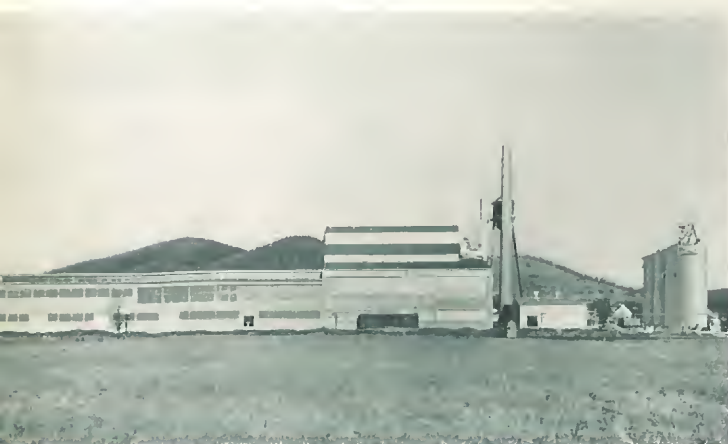
Processing basic products and transporting them to manufacturing plants demands specially built cars and containers.



River transportation provides bulk shipment of basic materials in special Company-designed barges.



Glass block—late comer to the building field—is a modern operation throughout. Specially-engineered machinery does an excellent job.



Modern plant for modern glass products—Port Allegany, the acme of glass plant modernization. Here glass blocks are made and Foaminglas becomes a reality.



Herculite, glass of superb strength, supports a modern automobile in dramatic three-point suspension.

freight and tank cars for transportation of both raw materials and finished products.

Its products were being distributed by hundreds of independent jobbers and dealers throughout the nation, in complete harmony with the Company-owned, and Company-operated, distributing warehouses. Foreign markets were developing, and many new domestic markets were in process of formation.

Well prepared, the Company entered upon a new era of prosperity—confident, resolute.

Although public acceptance and demand of its products had not been a problem, Company exploration into new markets convinced its officials that well-directed publicity could now be undertaken to good advantage.

The Glass Advertising Department was established in 1934. Its efforts were synchronized with sales development programs. It created a public consciousness of Pittsburgh Glass, aroused consumer interest and desire. It sponsored and supported promotional activities, merchandising campaigns, and established securely the trade names and uses of Company glass products.

One of its first and eminently successful undertakings was that of merchandising store fronts. As far back as 1912 the Company, to give the trade a more complete service, had developed a metal store front construction system called Easy-set. Its metal members were the Company's own design, manufactured for their exclusive use.

The increasing popularity of this type of service which combined important Company products made it desirable to provide a more utilitarian and distinctive metal store front construction and identify it with a trade name that could be uniformly applied to both product and service. In 1934, the name "Pittec" was coined by contracting the names Pittsburgh and Company and in 1942 was copyrighted to cover the entire store front construction as Pittec Store Fronts.

In 1934 a factory was established at Creighton for the fabrication of Pittec metal store front construction. This factory later was moved to Kokomo, Indiana, and became Works No. 19.

"Pittsburgh Mirrors" and "Made of Genuine Pittsburgh Polished Plate Glass" became recognized terms synonymous with pre-eminent quality.

A large number of the Company warehouses were equipped with silvering shops and manufactured mirrors, which augmented the production facilities of the Company's factory mirror plants. The Company was one of the first to adopt



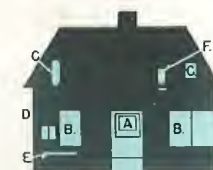
The Glass Center and other exhibits at the 1939-1940 World's Fair in New York provoked a modern world into a greater glass consciousness. The building housing the gorgeous display became a landmark of beauty.

the electrolytic "Copper Back" process for the protection of silvered surfaces which proved thoroughly practical.

The history of the Company has been a transition from the making of one basic product of interest to relatively few to a wide variety of products for the millions.

Company officials now decided they should disseminate information concerning their products, in view of the apparently unlimited opportunities for expansion. Company products and activities were publicized in national publications, on the nation's billboards, in dealer's show windows, and stores, by mail and personal contact and by nation-wide radio broadcast programs.

The Company was an important exhibitor at the Century of Progress exhibition in Chicago 1933-1934 where glass was featured extensively. A caravan of three specially built trucks containing miniature store front models toured the country, covered seventy-five thousand miles, and



AVERAGE SMALL HOME 1920

- A. DOOR PANELS, TRANSOMS
- B. WINDOWS
- C. MIRRORS
- D. FURNITURE MIRRORS
- E. STORM DOOR
- F. BOOK CASE

TOTAL GLASS VALUE \$45⁰⁰



AVERAGE SMALL HOME 1945+

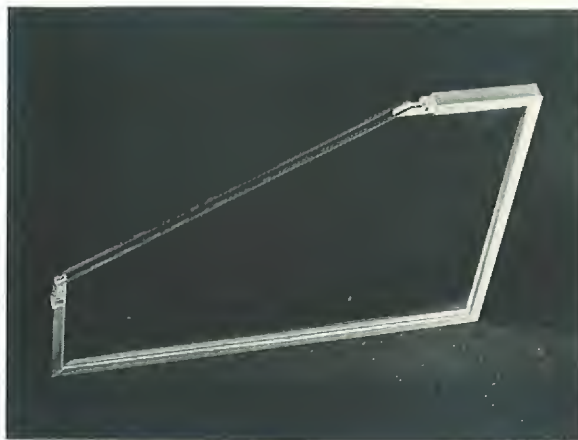
- A. STORM DOOR
- B. DOOR PANELS
- C. WINDOWS
- D. GLASS BLOCK EXTERIOR WALLS
- D. CARRARA BATH - KITCHEN
- E. MIRRORS
- F. FURNITURE TOPS
- G. GLASS INSULATION
- H. SOLARIUM
- I. MIRRORS, DECORATIVE
- J. SHELVES
- K. DOUBLE GLAZING
- L. PLAYROOM DECORATION
- M. GLASS PARTITIONS
- N. PICTURE WINDOW
- O. GLASS WINDOW SILL

TOTAL GLASS VALUE \$345⁰⁰

A GLASS MAN'S PICTURE



Placing storm windows to conserve heat in homes—a familiar October chore. A modern factory-built double glazed unit was created to permanently fill this need.



exhibited in three hundred fifty principal cities over a period of three years—1936-1939.

A comparatively new product, glass blocks, had been displayed at the Chicago Fair and was attracting favorable attention. Although their manufacture differed from that of flat glass, the Company decided to produce and market them. Accordingly, the Pittsburgh Plate Glass Company in cooperation with Corning Glass Works, long a leader in research and manufacture of technical glass products and one of the original manufacturers of glass blocks, incorporated the Pittsburgh-Corning Corporation in 1937. A modern plant was erected at Port Allegany, Pennsylvania; PC Glass Blocks came into being. The combined research and engineering forces of both companies proceeded to develop a superior product to be marketed through the distributing facilities of Pittsburgh Plate Glass Company.

New building construction became intensely active—a definite upward trend in the use of glass was the immediate result.

Carrara Glass wainscot used extensively in public and commercial buildings was successfully introduced into private residences for bathrooms and kitchens. Its exterior use was extended to cover facades of buildings, including service stations, and store front bulkheads.

Automobile production again approached the five million mark and with Safety Glass established as standard equipment, its closed car bodies consumed the major portion of all domestically

manufactured polished plate glass in addition to large quantities of sheet glass. Plate glass production had in 1936 reached the highest peak in the history of the industry amounting to about two hundred million square feet.

The evolution of Pittsburgh Hi-Test Safety Glass covers more than twenty years, has cost over six million dollars, and has involved tens of thousands of exhaustive experiments in both Company laboratories and those of collaborators. The development of a satisfactory plastic interlayer for the safety-glass sandwich, required intensive study of many different synthetic products until finally the vinyl resins were investigated. These resins have tremendous extensibility, with almost complete recovery of original dimensions, and at the same time are relatively slightly compressible. They present remarkable self-adherence to glass under heat and pressure, while other plastics required the intervention of a secondary adhesive. Pittsburgh Hi-Test Safety Glass, under impact, presents a characteristic yielding break with a "spider web" pattern, as contrasted with the "drum head," three or four-piece breaks of the earlier types. With each progressive improvement in Laminated Safety Glass, more and more of the state legislatures have enacted laws requiring Safety Glass in motor vehicles, until now the majority of the states have and enforce such requirements.

Multiple layers of various thicknesses of polished plate glass may be laminated into a single

unit which provides sufficient resistance to prevent the penetration of high powered rifle bullets. A Company product, Multiplate, bullet-resisting plate glass, is available in several types for armored equipment, tanks, etc.

The developments just enumerated call to mind the constantly broadening scope of research in the growth of the Company. Divisional research organizations had grown with the years. Constant product testing and the search for new processes and new products had begun to yield results. Colored plate glass in Blue and Flesh tints had become standard products. Solex, a heat-absorbing plate glass had been developed and adapted to many uses. Glass chalkboards were finding ready acceptance in their intended niche. The successful solution in 1933 of the long standing problem of producing tempered plate glass in large sizes was an invaluable research contribution and enrolled "Herculite" as one of the Company's outstanding products. The tempering process by which Herculite is produced imparts phenomenal strength and flexibility to glass, and enables it to perform extraordinary functions.

The Miracle of Glass—past, present, and future—as presented at The Glass Center, New York World's Fair, 1939-1940, was the greatest and most comprehensive glass display in history. In addition to The Glass Center building the Company exhibited an All-Glass House showing innumerable ways to use glass practically in beautifying and modernizing the home.

Full size Pitco Store Fronts lined both sides of a four hundred foot length on the Street Of Tomorrow, a feature of the Fair.

Millions of spectators viewed these exhibits, carrying away impressions which gave impetus

to the growing trend toward a more general use of glass. The combined effect of these exhibits with incessant and well-organized nation-wide publicity enabled the Company to successfully launch its residential-market campaign.

The small residential home building field, which normally consumed a relatively meager amount of window glass per house, was the objective. These were of the mass production type erected in large numbers by speculative builders, selling below five thousand dollars each.

It was proved that the average glass consumption could be increased many fold by the introduction of mirrors, glass block panels, structural glass, and miscellaneous items, especially larger window areas. This potential residential construction market was encouraging in view of unsettled world conditions.

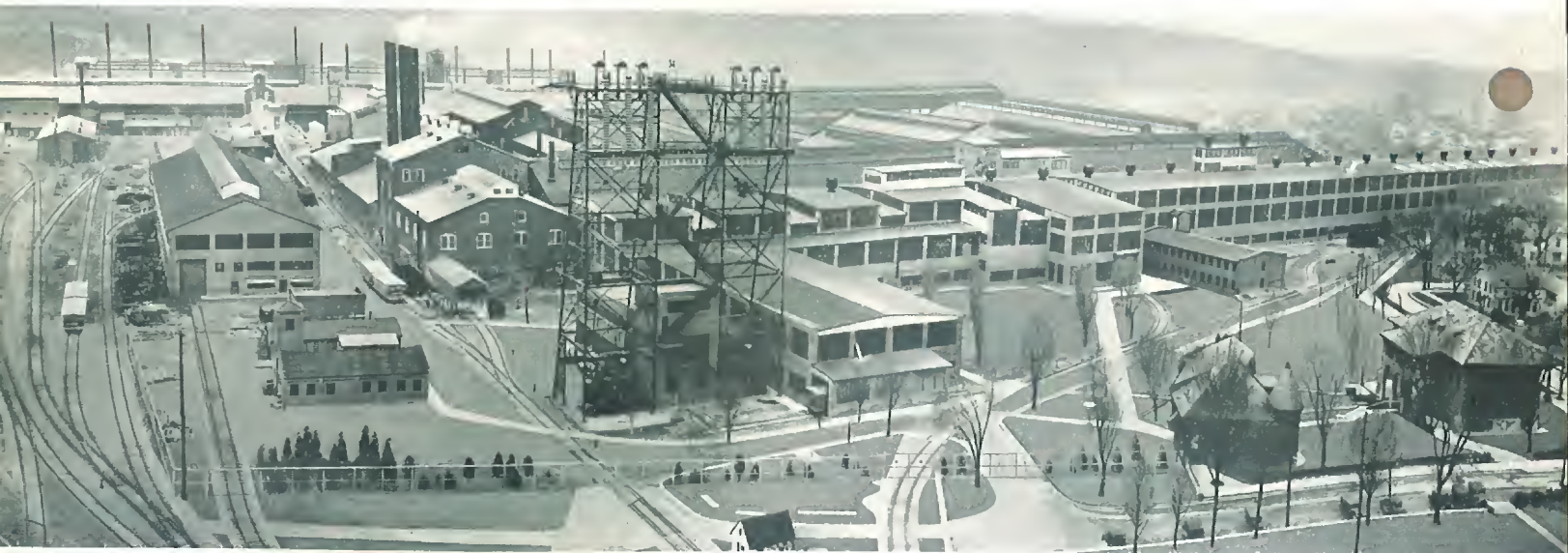
During 1941 Company operations were at or near capacity levels. Although the United States was not then at war, the national defense program was in operation. Company laboratories and plants, recently expanded and improved, stood ready to serve the country's needs.

Bullet-Resisting Plate Glass, unknown during World War I, was now finding widespread use in aircraft and other military equipment. Ships, tanks, and implements of war were using Herculite Tempered Glass also, in large quantities.

Under the impetus of national emergency and increased demands of the aviation industry for a glass that would meet the unusual requirements of stratosphere and stratosphere planes, Company engineers developed a new and superior product. Flexseal Laminated Safety Glass, many times more resistant to impact than regular Safety Glass, was instantly successful and contributed



World War II found the Company able to throw its vast resources and skills into a pace-setting fury of research and production. Safety or laminated glasses were standard equipment of every plane, tank and ship.



A modern factory making modern glass for a modern world. Crystal City, one of the original and now one of the newest plate glass factories of the Company. In the foreground—right—the hospital.

substantially to the remarkable performance and durability of American-built war planes.

In 1941 H. S. Wherrett was appointed Vice Chairman of the Board of Directors, being succeeded in the Presidency by R. L. Clause, son of W. L. Clause, first Sales Manager of the Company and former President. H. B. Higgins became Executive Vice President.

The attack on Pearl Harbor on December 7,

1941, marked the beginning of America's participation in World War II. Restriction on private building construction, automobile manufacture, curtailment of nonessential production and conversion to the making of war materials resulted in the loss of large glass-consuming markets. To partially offset this came the accelerated production of war planes, ships, tanks, trucks, and demands of industries producing every type of war equipment whose requirements involved large quantities of glass.

And now came another timely development in glassmaking engineered by Pittsburgh Plate Glass Company and Corning Glass works. After years of painstaking research, a radically new type of glass—Foamglas—was made by a cellulating or foaming process, one of the most amazing developments in glassmaking history.

Glass in its wide adaptability was now offered to American industry to supplant critical materials. Glass technicians were available for field investigation of industrial problems. A surprising number of important new applications involved the use of large quantities of glass. In many instances glass has proved more satisfactory than the material replaced, and its use will be permanent. Many new markets were thus discovered.

Conservation of fuel for heat proved a benefit to the glass industry. Double glazing, an effective insulation against heat loss, lowered fuel consumption. The demand for glass in storm sash or



A complete chemical and physical laboratory with up-to-the-minute equipment and personnel long has been a Company standard.

winter windows materially augmented the market demands for window glass.

Pittsburgh double glazed insulating units, in which two or more lights of glass are sealed with an air space between, were developed after painstaking laboratory research and test installations in the wartime field. Their many wartime uses, where clear vision together with insulation is essential, will be extended and greatly enlarged in peacetime equipment and construction markets.

In August 1943 the Pittsburgh Plate Glass Company had completed 60 years under its corporate name.

Its original capitalization of six hundred thousand dollars had increased more than a hundred times, to sixty-five million dollars. Beginning with one plate glass factory, it now owns and operates seven flat glass factories. The four plate glass fac-

tories produce more than five times as much polished plate glass as did all the nine plants together in 1893; and the three Pennvernon window glass plants produce nearly as much as all the factories in the country did when the Company entered the field in 1907. In addition, the Company operates a glass block and Foamglas factory owned jointly with Corning Glass Works. It also owns and operates a Pitco Store Front Metal factory.

In addition to these, it owns and operates ten paint division factories, four chemical division plants (one of which is owned jointly with American Cyanamid Company), one cement plant, one brush factory, and one brush handle factory, and also one plate glass factory at Courcelles, Belgium.

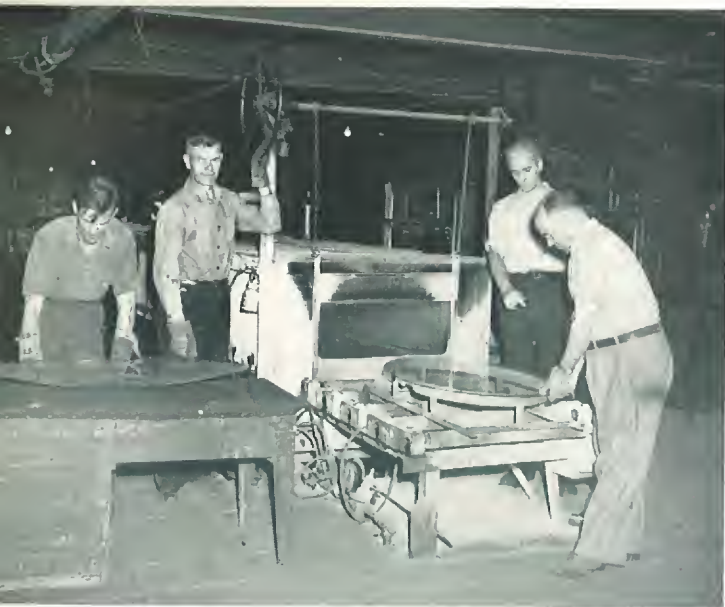
Twenty-nine Company manufacturing units produce important materials in three major industries—Glass, Paints, and Chemicals.



All new glasses and new uses of glass start at the laboratory. Here a test piece of Herculite goes into the laboratory annealing furnace. The engineer must plan the equipment as well as the process.



Experimental stages in seeking new processes for producing complex bends in glass.



A Laboratory annealing lehr receives a searchlight cover glass.

Between the factories and the consuming markets are the Company-owned and operated distributing warehouses and stores which cater to the trade.

Seventy-six warehouses and seventy-seven Company-operated stores distribute Pittsburgh Glass,

Paints, Brushes, and Sundries, in principal cities, east of the Rockies. In the West Coast territory where an additional forty-three Company stores distribute only Pittsburgh Paint products, the glass products are sold through W. P. Fuller and Co. In addition, Company products are distributed by hundreds of independent jobbers and thousands of dealers throughout the land.

It is an interesting fact that the average length of service for all of the warehouse managers is twenty-four years and their average age is forty-seven. As a group they have been with the Company since they started to work—and practically all of them have risen from the ranks.

The Pittsburgh Plate Glass Company organization of employees and stockholders made possible the successful functioning of these producing and distributing units. More than nineteen thousand people comprise the Pittsburgh Plate Glass Company organization. Of this number, fifteen thousand are factory employees and nineteen hundred are engaged in various types of fabrication in warehouses and stores—men and women whose skilled hands and talented minds obtain and assemble the raw materials, manufacture the products, process and fabricate and otherwise prepare them for sale. Some twenty-two hundred others look after the mass of detail which surrounds all such enterprises; supervise and manage the activities; study, plan and build; safeguard and protect health, property, and other Company interests and sell and distribute its products.

Fully a third of the number has been with the Company longer than ten years, half of the total number more than five years.

Collectively, they represent the greatest asset of the Company; material and resources and costly equipment are useless without efficient men and women to handle and operate them.

The capital stock of the Pittsburgh Plate Glass Company is held by approximately eight thousand three hundred persons, including many Company employees and many women. These stockholders elect the eleven members of the Board of Directors, eight of whom are its highest officers with an average service of over thirty years. Theirs is the responsibility of establishing and carrying out policies which maintain the high standards of the Company. Most of them have risen to authority from positions of low rank after many years of faithful service.

Thousands of Company people have served in the armed forces—many have made the supreme

sacrifice and will never return. They have contributed with all the others—employees, officers, directors, and stockholders, each in his own way—to the making of Company history.

There is no more creditable achievement in all the annals of American industry than that of the Pittsburgh Plate Glass Company. It illustrates the diffusion of the founder's work and accomplishment through successive generations of conscientious progressive management.

The corporate entity that is Pittsburgh Plate Glass Company today honors the memory of John Pitcairn and of those who, like him, contributed to its success. The year 1944 started auspiciously with the promotion of Company executives.

Clarence M. Brown, who forty-nine years earlier was employed by the founder and remained his intimate associate for twenty-one years, who served as a member of the Board of Directors for forty years (thirteen of those years as Chairman) now became Chairman of the Finance Committee.

Harry S. Wherrett, who fifty-three years prior started as an office boy and rose from that lowly position to the Vice Chairmanship of the Board, now became Board Chairman.

R. L. Clause, who joined the Company as a draftsman in the Manufacturing Department thirty years before, had risen to the Presidency, and now became Vice Chairman of the Board.

H. B. Higgins, who had diligently and efficiently served the interests of the Company through forty



Bodies are specially constructed to carry glass in the safest possible manner—on edge.



A modern Company truck that has been carefully engineered by the design department to facilitate handling and transportation of glass and paint. A handsome delivery truck is good publicity for the Company—so a seasonable poster is applied to the rear panel of the trucks to further the message of glass and paint.



A typical store exterior. The building must be a credit to the community and spread the gospel of clean-up, paint-up.



Store interiors must convey to the public the importance of glass and paint. "Better living through glass" sums up its mission.

years of association in many capacities from stenographer in a warehouse to that of Executive Vice President, was made President.

The success stories of these outstanding men whose years of service and ability were thus rewarded may well serve as an inspiration to every employee. Not all who struggle can reach the pinnacle; but success is attained in varying degrees, and many with the organization have, and will continue to have, the satisfying experience of effort well rewarded through advancement, for such is the Company policy.

The prosecution of the war brought marked changes in Company operations. An urgent demand for new and specialized products, the startling variety of mobile units for land, sea, and air warfare that continue to roll from converted production lines and shipways require special types of glass—glass of many thicknesses, bent to intricate shapes, tempered, laminated and assembled, and all to exacting specifications.

Their production involves many problems which are only overcome by concentrated research and engineering, but the knowledge gained will be of immense benefit in the postwar production of consumer goods.

More than five thousand former employees are now in the armed forces. President Higgins, in letters to the men themselves, to their families, and to their former managers or superintendents, has announced the broad human policy of the Company toward the re-employment of these returning veterans. This action, among the first to be taken by any large industrial corporation, is in keeping with the Company's attitude toward and interest in the welfare of all its employees.

On August 13, 1944, death claimed Harry S. Wherrett, who started his business career as office boy with the Diamond Plate Glass Company fifty-three years before and progressed through the ranks to Chairman of the Board of Directors of the Pittsburgh Plate Glass Company.

Clarence M. Brown again became Chairman of the Board, and his son, Howard B. Brown, for some time Secretary of the Company, was elected to fill the vacancy on the Board of Directors.

What has occurred is now recorded; the heritage of every individual member of the organization. Regardless of rank or position, those who comprise the Company are daily contributing to the molding of its future.

The Officers and Directors of the Pittsburgh Plate Glass Company in 1945 are as follows:

BOARD OF DIRECTORS

C. M. BROWN, *Chairman*

R. L. CLAUSE, *Vice Chairman*

Raymond Pitcairn	Richard K. Mellon
J. H. Heroy	E. D. Griffin
H. B. Higgins	E. T. Asplundh
Harold F. Pitcairn	R. B. Tucker

Howard B. Brown

OFFICERS

C. M. BROWN *Chairman of the Board,
Chairman of the Finance Committee*

R. L. CLAUSE *Vice Chairman of the Board*

H. B. HIGGINS *President*

J. H. HEROY *Vice President, Brush Division*

E. D. GRIFFIN *Vice President, Paint Division*

E. T. ASPLUNDH *Vice President, Chemical and
Cement Divisions*

F. W. JUDSON *Vice President*

R. B. TUCKER *Vice President*

LELAND HAZARD *Vice President, General Counsel*

JOHN A. WILSON *Manager of Glass Manufacture*

W. V. SIMMONS *Treasurer*

HOWARD B. BROWN *Secretary*

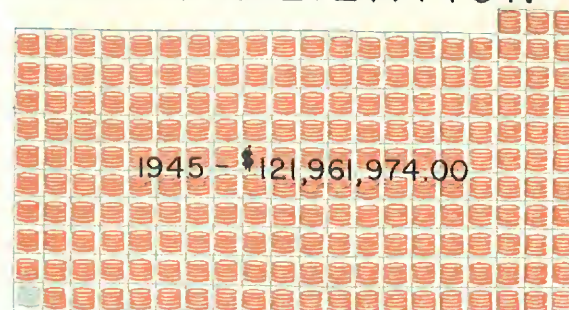
C. R. FAY *Comptroller*

*This outline of history portrays the
Pittsburgh Plate Glass Company—
maker of glass—the material that
contributes so much to the making
of history.*

CAPITALIZATION

From less than a million to over 120 million in just over 60 years is the financial history of the Company.

EACH RED SYMBOL= $\$600,000$.

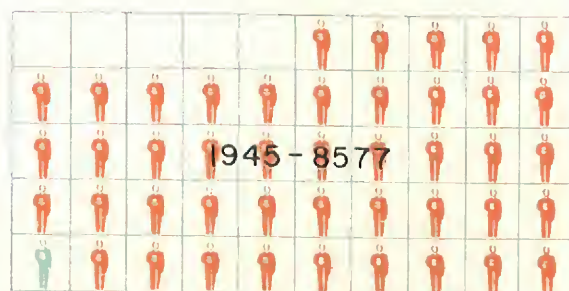


1883 - $\$600,000.00$

STOCKHOLDERS

From 102 to 8,577 stockholders in the last 56 years of Company history.

EACH RED SYMBOL= $\frac{200 \text{ STOCKHOLDERS}}{1}$

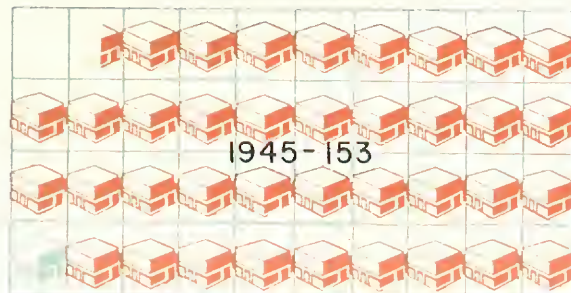


1889 - 102

DISTRIBUTION CENTERS

From a few small dealer shops to 153 efficient outlets in 49 years of merchandising.

EACH RED SYMBOL= $\frac{1 \text{ CENTERS}}{1}$

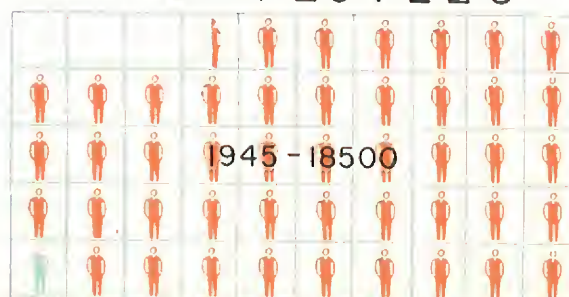


1896 - 4

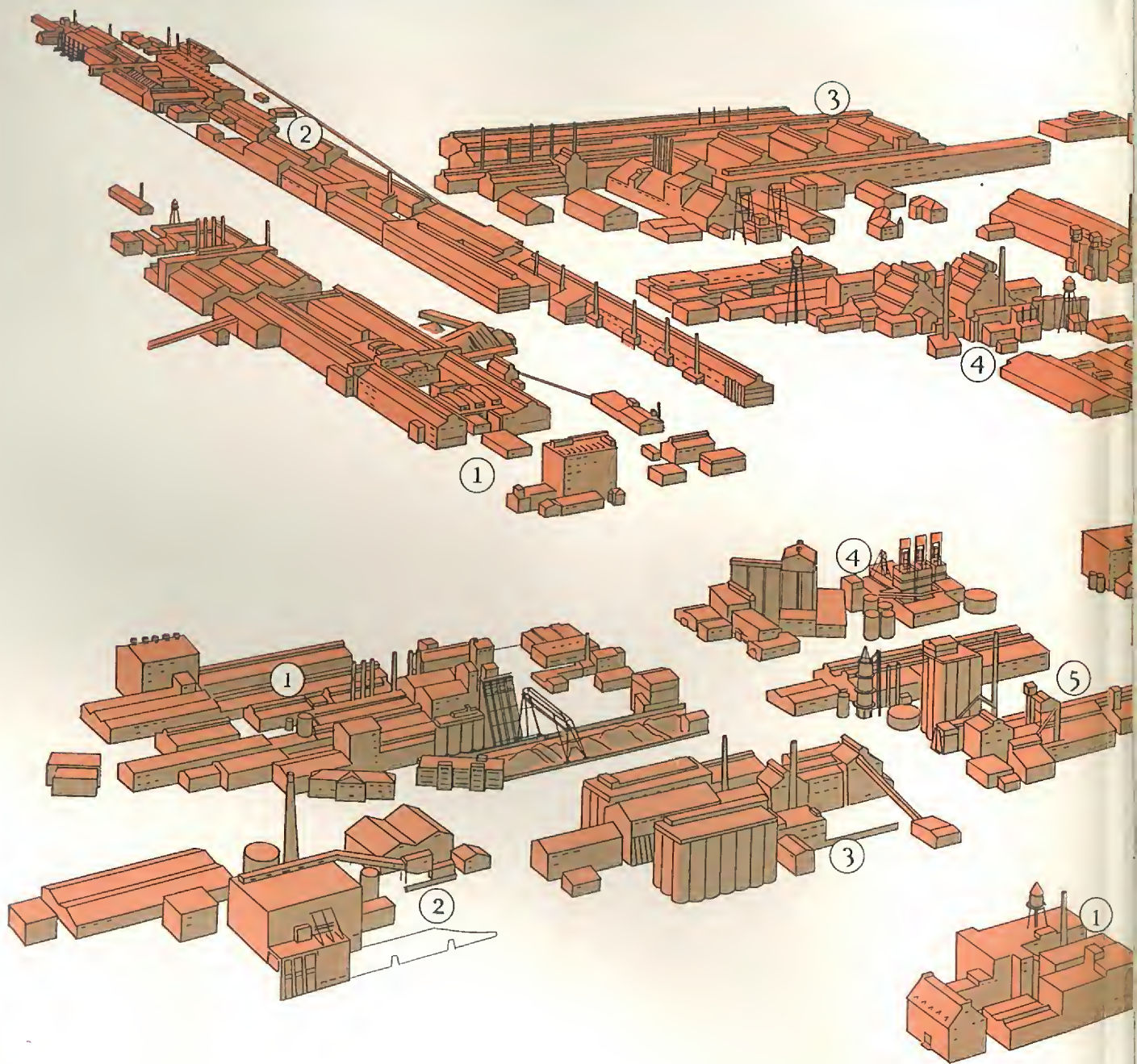
EMPLOYEES

In 1915, the Company employed regularly an average of 18,500 persons. Of October 1, there were 6,051 in the Armed Service.

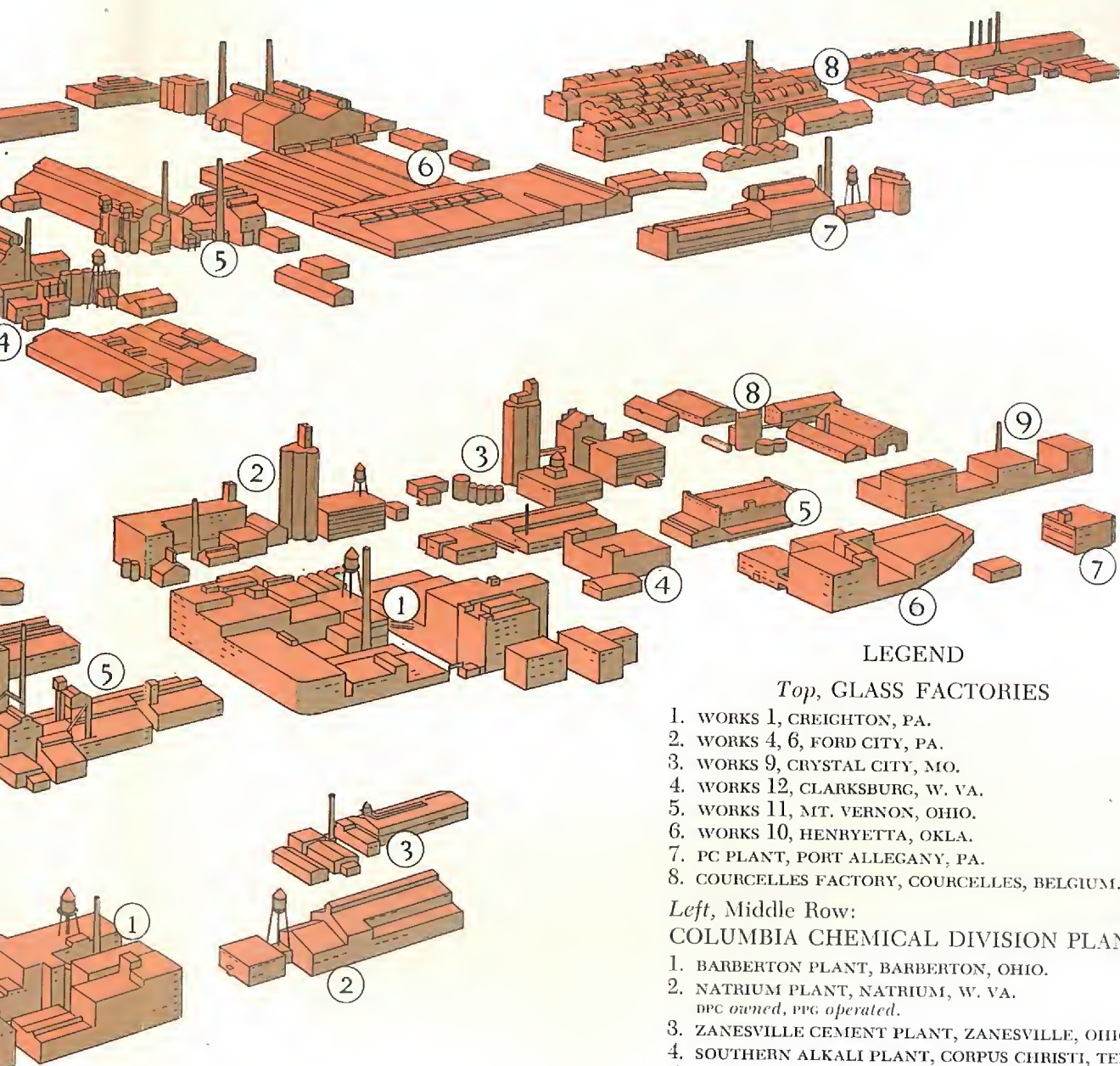
EACH RED SYMBOL= $\frac{400 \text{ EMPLOYEES}}{1}$



1883 - 200



COMPOSITE PERSPECTIVE OF THE MANUFACTURING UNITS OF
PITTSBURGH PLATE GLASS COMPANY



LEGEND

Top, GLASS FACTORIES

1. WORKS 1, CREIGHTON, PA.
2. WORKS 4, 6, FORD CITY, PA.
3. WORKS 9, CRYSTAL CITY, MO.
4. WORKS 12, CLARKSBURG, W. VA.
5. WORKS 11, MT. VERNON, OHIO.
6. WORKS 10, HENRYETTA, OKLA.
7. PC PLANT, PORT ALLEGANY, PA.
8. COURCELLES FACTORY, COURCELLES, BELGIUM.

Left, Middle Row:

COLUMBIA CHEMICAL DIVISION PLANTS

1. BARBERTON PLANT, BARBERTON, OHIO.
2. NATRIUM PLANT, NATRIUM, W. VA.
DPC owned, PVC operated.
3. ZANESVILLE CEMENT PLANT, ZANESVILLE, OHIO.
4. SOUTHERN ALKALI PLANT, CORPUS CHRISTI, TEX.
5. PACIFIC ALKALI PLANT, BARTLETT, CALIF.

Right, Middle Row:

PAINT DIVISION FACTORIES

1. MILWAUKEE DIVISION, MILWAUKEE, WIS.
2. NEWARK DIVISION, NEWARK, N. J.
3. RED WING LINSEED OIL DIVISION, RED WING, MINN.
4. HOUSTON FACTORY, HOUSTON, TEXAS.
5. PORTLAND FACTORY, PORTLAND, ORE.
6. DITZLER COLOR DIVISION, DETROIT, MICH.
7. LOS ANGELES PAINT DIVISION, LOS ANGELES, CALIF.
8. THRESHER VARNISH CO., DAYTON, OHIO.
9. MONTREAL PLANT, MONTREAL, CANADA.

Bottom

1. BALTIMORE BRUSH PLANT, BALTIMORE, MD.
2. PITCO METAL PLANT, KOKOMO, IND.
3. BRUSH HANDLE PLANT, KEENE, N. H.

A-3

GLASS . . . ITS COMPOSITION

Al
Sb
As
Ba
Be
B
Cd
Cs
Ca
C

Ce
Cl
Cr
Cu
Co

LIME
CaO

SAND
SiO₂

SODA
Na₂O

Di
F
Au
Fe
Pb
Li
Mg
Mn
Na
Ni
N
O
P
K
Pr
Se
Si
Ag
Sr
S
Sn
T
U

GLASS



The elements of matter from which glass is compounded are among the most abundant in the world

There are exactly 92 distinct and unique chemical elements. In various combinations and arrangements they constitute heaven and earth, the sea and all that in them is. On the average, out of 6 atoms of matter forming the earth's crust, 3 are oxygen, 1 hydrogen, and 1 silicon. The 89 other elements comprise the remaining part.

SINCE natural glass (obsidian) is found widely disseminated through the world, it is not surprising that in the great drama of glass manufacture some 41 of these elements play a part. Some have stellar roles and some only very limited ones. Some are quite essential to satisfactory glass production, while others are purely incidental to the necessary use of other elements with which they may be combined. Some of them enter definitely into the glass composition, while others impart to the glass certain characteristics either by solution in it or by the colloidal suspension of particles in the glass body.

Ordinarily the chemical elements enter in one way or another into the production of glass in the form of their oxide (combined with oxygen); sodium oxide, calcium oxide, and silicon dioxide (2 atoms of oxygen to 1 of silicon) are the principal components. These are commonly

known as soda, lime, and silica. Although there are many types of glass, nonetheless the soda-lime-silica glass of the ancients is the foundation of all present-day products, including those manufactured by the Company. All of the newer or special glasses have been produced by substituting one or another ingredient for one or more of the fundamental ingredients of soda, lime, and silica or sand.

As shown on the accompanying ternary or three-component diagram, only a very small part of all the possible combinations of the three components will produce transparent glass.

A typical glass batch contains more than 70% sand, approximately 13% soda, and an equal amount of lime. The relationship of terms between the base elements from which these materials are derived and their popular names is interesting, as also their chemical symbols by

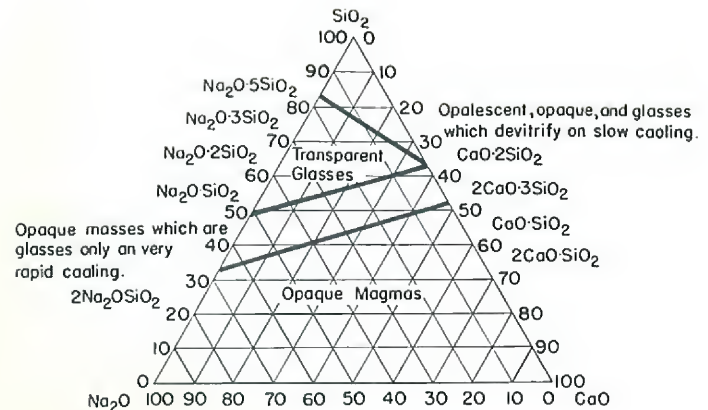
which they are designated in technical papers.

Name	Symbol
Silicon	Si
Silicon Dioxide	SiO ₂
Silica	SiO ₂
Sand	SiO ₂

Name	Symbol
Sodium	Na
Sodium Carbonate	Na ₂ CO ₃
Soda Ash	Na ₂ CO ₃
Soda	Na ₂ O

Name	Symbol
Calcium	Ca
Calcium Oxide	CaO
Limestone	CaCO ₃
Lime	CaO

Sand has been formed through the ages by the action of the various glacier periods, and by the force of water rolling rocks against each other, either in mountain streams or on the seashore. Throughout the geologic ages, many deposits of sand have been made which have been converted into sandstone by the pressure of the overlying ground or in other ways. These sandstone deposits have been subjected to the action of rain and surface water and all of the impurities contained in the original deposit washed away. Consequently, most of the sandstone quarries yield nearly pure silica.



Glass in its chart form and surrounded by its relatives.

The sand found along the seashore and along present river beds usually is not suitable for glass-making, because it contains too many impurities which can be removed only by costly washing. Some seashore beach sand would make excellent glass, but cannot be satisfactorily or economically transported to distant factories. In most instances, better glassmaking sand can be obtained by mining from natural sandstone deposits at much lower costs. Such a natural deposit is part of the St. Peter strata in eastern Missouri, running from 50 miles northwest of Crystal City to a hundred



The distribution of sand, soda (salt) and limestone in their deposited state based on federal statistics.



An electrified shovel bites into silica strata at Crystal City, Missouri. The strata here, over 28 feet thick, lie below the Mississippi and come to the surface at the factory. An electric engine moves the loaded cars to a conventional tippie.

miles southeast, and ranging from 25 to 100 feet thick. It yields approximately 99.8% pure silica; fine, round-grained, easily crushed, white sandstone; a perfect, natural substance, which goes into the making of Pittsburgh Glass.

The existence of this deposit influenced the location of the Crystal City factory, Works No. 9, which adjoins the company-operated sand mine. At the mine, the stratum is about 65 feet thick. Tunnels are bored through a 30-foot middle layer, half the stone is removed, the remainder is left in pillars to support the roof. Crews of men with drills, explosives, electric shovels, and a railway system remove a ton of sand every minute. It is estimated that at this rate the supply will last for many years to come. Other important sand mines are located at Hancock, Maryland; Ottawa, Illinois; Lewistown and Mapleton, Pennsylvania; Roff, Oklahoma; and Howard, Ohio. There are

no other known high-grade deposits of sand between the Allegheny mountains and the St. Peter strata.

For plate glass and window glass, sand having a content of 99.9% silica and not more than 0.05% iron oxide is required. For optical glass, the content of iron oxide must be under 0.02%. For bottle glass and numerous other glass products, the purity of the silica is not so highly important as the color and quality of such products indicate, although for decolorized pure white bottle glass, the iron content must usually be less than 0.1%.

Sand or silica, which is converted into glass by the action of heat, is very difficult to fuse, requiring extremely high temperatures. Only some such fortuitous discovery as that related by Pliny, revealed that other materials, in that instance natron (soda), melted in close contact with the sand, would permit the melting of silica at much



A salt well in the modern manner—the house at the base houses the pumping equipment. An electric motor does the work efficiently.

lower temperatures. Such materials are known as fluxes and it would seem that soda was probably the first flux discovered. Soda derives its name from sodium (Na, natrium) which is found very widely disseminated throughout all the earth, in many different chemical combinations. The almost universal presence of sodium is evidenced by the fact that most materials introduced into the flame of a Bunsen burner will produce a brilliant yellow color. This is known as "monochromatic light" to which our eyes are extremely sensitive. A familiar use is in the "sodium-vapor lamps" that illuminate many highways.

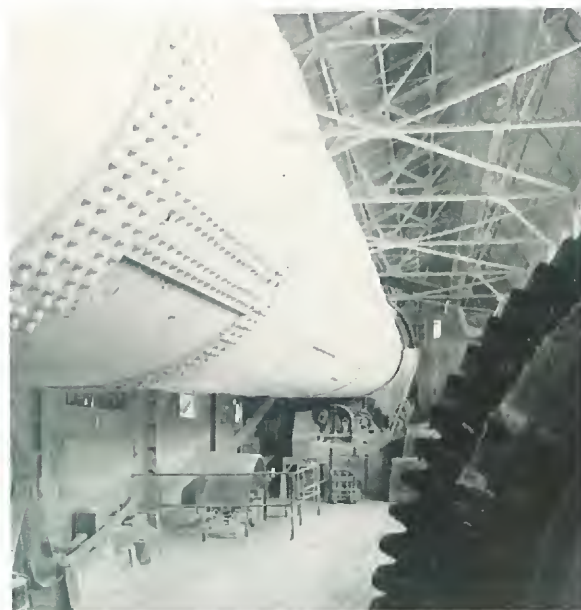
Soda used in glassmaking is very closely related to the baking soda or sodium bicarbonate used in the home. Sodium carbonate which is also known as soda ash is used at home in the form of "sal soda." Most of the soda used in the glass batch is derived from sodium carbonate although some is also derived from sodium sulphate, which is commonly known as salt cake, and when crystalline, as "Glaubers Salt." Ordinary table salt, or the salt in sea water is principally sodium

chloride which is also to some extent used in glass-making. These are but a few of the many salts containing sodium in its various forms.

Soda ash, which goes into the making of Pittsburgh Glass has been produced since 1889 by the Columbia Chemical Division at Barberton, Ohio. Here are abundant, underground deposits of salt, varying from 10 to 80 feet in thickness and located about 2800 feet below the surface. In 1900 engineers drilled the first salt well. Water was forced into the salt bed, dissolving the upper layers. The brine solution was pumped to the surface. A steady supply of salt is now furnished by 14 wells on the Company's property. This salt (sodium chloride) is then processed and converted into soda ash (sodium carbonate) and shipped to Company glass factories.

The powerful fluxing agent without which the founding of glass would be almost impossible, is the sodium oxide derived from sodium carbonate or sodium sulphate. In the founding process the carbonate or sulphate is decomposed and only sodium oxide remains. Sodium oxide does not occur in nature and can only be produced by such high heat as is developed in a glass furnace.

When a mixture of sand and soda is heated, the soda melts and the sand dissolves in the molten soda forming sodium silicate. Depending upon the relative proportions of sand and soda this sodium silicate is more or less soluble in water.



This 9' D. x 175' L. Rotary kiln converts limestone into lime. A kiln of this size produces 200 tons per day.

It is commonly known as waterglass. While there are many commercial uses for sodium silicate in this form, it is not suitable as a glassmaking material. Something else must be added to make a satisfactory glass.

The introduction of lime or calcium oxide, into the glass batch, in correct proportion, results in forming a soda-lime-silicate, which is virtually unaffected by moisture or acids. It renders the glass more viscous at the working temperature, shortens the setting time, and improves weathering of the glass product. Glasses high in lime content are usually spoken of as "hard" glasses because of the difficulty experienced in working them in the old days of the hand-operated factories. Nature has been most prolific in distributing calcium from which lime is derived. The coral atolls of the south seas are principally lime, as are all coral formations. So is the wood in petrified forests.

Lime is introduced into the batch mix for almost all glasses, usually in the form of limestone, which is obtained from quarries in the vicinity of Bellefonte, Pennsylvania, eastern Missouri, and Maryland. Limestone actually is marble, such as is used for statuary and building construction. It is the basis of all the various kinds of Portland cement which are used in making concrete. Raw limestone is calcium carbonate. In some glass-making practice it is calcined or roasted before being mixed into the batch. It is entirely a matter of opinion of the glassmaker as to whether raw lime, calcined stone, or burned lime is the best material to use.

Limestone containing large percentages of magnesium oxide, usually called dolomitic limestone or dolomite, is obtainable almost anywhere through the state of Ohio, in eastern Pennsylvania and in western Arkansas.

These three elements of matter, silicon (sand) making up one-quarter of the earth's crust, sodium (soda) whose presence is universal, and calcium (lime) abundantly deposited, in the form of their oxides combine in forming the base glass from which virtually all others are derived. Plate glass, window and sheet glass, bottle and container glass, all belong in this family. The principal differences between these three types lie in the quantities of sodium and calcium used in them.

Of the other elements involved in glassmaking, some may be substituted for one or another of these basic materials. Their effect is to materially



Limestone is mined as shown in the illustration. Air conditioning is here essential to the comfort of men 700 feet below the earth's surface.

modify the characteristics of the resultant glass products. Sodium, potassium, and lithium are entirely mutually interchangeable. Aluminum, magnesium, barium, boron, or lead may be substituted for calcium. Aluminum, boron, or titanium to some extent may be used instead of silicon, while phosphorus may entirely supplant the silicon. All the other elements enter into the glass composition simply to affect color, viscosity, permanence, or to impart some other desired physical property.

All of these elements are identified in the following alphabetical listing, together with their chemical symbols, source, purpose, and effect, in the making of glass.

ALUMINUM (Al) in the form of aluminum oxide, acts either as a base or an acid. That is, it may supplant either the lime or the silica of a normal glass in greater or lesser proportions. Even very small percentages of alumina tend to increase the viscosity of the glass at the working temperature as well as the resistance to weathering. Alumina must be used rather cautiously,

because it also renders the glass more difficult to fine and tends to make the glass cordy and reamy.

Aluminum metal used in industry is almost wholly derived from bauxite by an electrolytic process. The alumina used in the glass industry is principally derived from feldspar, of which the best grades come from South Dakota. There are also large deposits in Colorado, Tennessee, and New Hampshire. Aluminum is the principal ingredient of the precious stones sapphire and ruby and of the abrasive material corundum. The gems are pure transparent aluminum oxide while the abrasive corundum is opaque.

ANTIMONY (Sb) in the form Sb_2O_3 is obtained from China and Bolivia and is presently being produced in the United States. It acts as a "fining" agent in the glass melt and tends to alter the greenish cast of the glass due to the presence of iron impurities.

ARSENIC (As) in the form As_2O_3 , a by-product of copper refining, obtained principally from Mexico, is used for the same purposes as antimony.

BARIUM (Ba)—Barium oxide is derived from barium carbonate in the actual melting of the glass batch. In this country, the barium carbonate is produced from barytes or heavy spar by chemical processes. Barium oxide may be used to supplant the lime to any desired extent in the fundamental glass batch. It is used principally in optical and ophthalmic glasses to increase the index of refraction.

BERYLLIUM (Be) introduced as beryllium oxide, BeO , may act either as an acid or a base, just as in the case of aluminum. It tends to increase the index of refraction and to yield a more stable glass with respect to weathering. It is very expensive and is very slightly used.



BORON (B) in the form of boric acid, $B_2O_3 \cdot 3H_2O$ acts as an acid generally. Introduced into a glass batch it increases the index of refraction. It tends to deepen the color produced by various other coloring materials. It may be substituted either in whole or in part for the silica of a glass melt. It tends very greatly to reduce the coefficient of thermal expansion of the glass.

Boric acid is found in the great California deserts of the United States as a natural deposit of very fine granular material. It is widely used in optical and ophthalmic glasses, and is one of the chief components of the ovenware glasses currently available in the market.

CADMIUM (Cd) in the form of cadmium sulphide, CdS , produces a yellow glass. The color is modified by "striking." It is used particularly in optical filter glass, since it absorbs certain portions of the spectrum. Most of the cadmium used in this country is obtained from Great Britain.

CAESIUM (Cs) as CsO may be used to entirely or partially supplant sodium. However, it is very sparingly used because of its extreme scarcity and very high cost. It also tends to increase the index of refraction. It is one of the rare metallic elements.

CALCIUM (Ca) is one of the basic glassmaking elements introduced as lime or limestone and previously discussed in detail.



CARBON (C) is used as an agent to modify the melting of other materials which may be present. Although it forms a part of almost every glass batch, it may well be considered "Peck's Bad Boy" of the glass industry, since its action is sometimes very hard to control. It helps to increase the boiling action of the melt since in process of reducing other ingredients it forms carbon dioxide, which is driven off in that form. Ordinarily, carbon is introduced into the batch in the form of anthracite coal, breeze or buckwheat size.

CERIUM (Ce) as Ce_2O_3 , is usually more or less impure, as obtained commercially. The commercial product usually produces a slight yellow tint and a blue fluorescence in the glass. It is used in special ophthalmic glasses to absorb certain portions of the spectrum. Cerium is a North Carolina product.

CHLORINE (Cl) is usually introduced in the form of sodium chloride, $NaCl$. Very small amounts are used to help agitate the batch which tends to improve the quality of the glass. The chlorine is derived from pure white table salt, which is largely obtained from wells in the vicinity of Barberton, Ohio, and of course is obtainable throughout the world.

CHROMIUM (Cr) in the form of chromic oxide, Cr_2O_3 , produces a yellow-green color. It is used in some ophthalmic glasses to absorb certain portions of the spectrum. It acts as an oxidizing agent in a glass melt.

COBALT (Co) in the form of cobaltic oxide, Co_2O_3 , is obtained principally from the refining of Canadian nickel ores. A very small trace of cobalt in a glass produces a blue color, the intensity increasing with the amount of cobalt present. It is sometimes used as a decolorizer, just as bluing is used in household washings to whiten clothes. Used in combination with nickel, it yields a neutral tint glass sometimes used in the ophthalmic field.

COPPER (Cu) in a glass melt is a rather versatile material. It may be used either as cuprous oxide, Cu_2O , or as cupric oxide, CuO . Under oxidizing conditions in the furnace, it produces a blue color in the glass, while under reducing conditions, introduced either as the native metal or as the cuprous oxide, it will produce a red color, after "striking." Copper is produced all over the world and may be obtained from many different countries.

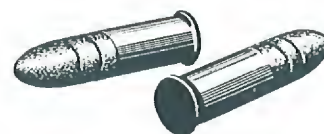
DIDYMIUM—no longer classed as an element but a combination of neodymium and praseodymium. Glasses containing these elements have a bluish pink cast.

FLUORINE (F) acts as an opacifier or opalizer in a glass. It lowers the index of refraction and lowers the viscosity of the glass at the working temperatures. It is usually introduced in the glass in the form of fluorspar, although other minerals are used. The fluorspar which the Company uses comes from Kentucky.

GOLD (Au) usually introduced as the chloride will produce a beautiful ruby color, which is enhanced by the presence of tin. The metal is present in the glass in the form of a colloidal suspension. Gold very greatly increases the density of the melt. It is very little used as a colorant, particularly because of the very high cost.

IRON (Fe) is usually present in almost all batch materials as an impurity. In the form of ferric oxide, Fe_2O_3 , it is deliberately added to glass batches to produce an aquamarine color. In the presence of reducing agents and reducing conditions in the furnace, the Fe_2O_3 is reduced to the ferrous condition, FeO . The ferric iron is highly absorptive of ultra-violet radiation and ferrous iron is highly absorptive of infra-red. It is never possible to completely oxidize or reduce the iron.

Iron tends to lower the viscosity of the glass at melting temperatures, which is helpful, and accounts for the amounts permitted to be present in some glasses. As used in glassmaking, iron is usually introduced in the form of rouge, Fe_2O_3 , which is obtained by the burning of copperas or by precipitation from a solution of copperas in the form of ferric hydrate. The copperas is obtained from the pickling liquor used in steel mills to clean their products.



LEAD (Pb) in the form of lead oxide, PbO , is introduced into the glass to increase brilliance, density and refractive index. In general, it is without effect upon the whiteness of the glass, while in large percentages it lends a canary yellow color. It is used in high-grade tableware, so-called "cut crystal," optical glasses, ophthalmic glasses, and in X-ray absorptive glasses. Our X-ray lead glass consists of 60 to 61% lead oxide. There is no lead in normal plate glass or window glass. Optical and ophthalmic glasses containing lead are known as flint glasses; in other fields, clear colorless glasses, even though containing no lead, are frequently known as "flint glasses." Care must be exercised to distinguish what type of "flint" glass is under discussion. The original meaning of the word was simply a clear white glass, derived from the use of flint stone, in England, to melt glass. Later, when it was found that these flints also contained lead, the name was applied to any brilliant white glass. Most of the lead used in the United States comes from Missouri, and is used in the form of "litharge, sublimed lead oxide."

LITHIUM (Li) belongs in the same general class with caesium. That is, it is a flux which may entirely supplant the sodium oxide, but is seldom used because of its cost.

MAGNESIUM (Mg) is usually introduced into the batch in the form of dolomitic limestone which must contain at least 22% of magnesium oxide. Magnesium may entirely supplant the calcium oxide in a glass batch, if desirable. This tends to decrease the index of refraction of the glass, thereby decreasing the brilliance. Partial substitution lengthens the setting time and lowers the devitrification temperature. It tends to lower

the coefficient of expansion of the glass and to increase its resistance to abrasion. It is now a very usual component of window glass or sheet glass.

MANGANESE (Mn) is obtained in Russia, Cuba, Malaya, and Africa, in the form of manganese dioxide, MnO_2 . Small quantities may be used as decolorizers for iron. In the early days of glassmaking in the United States this was practically the only decolorizer used. After prolonged solarization, glasses decolorized with manganese tend to develop the deep purple color of the permanganates, as may be observed in many windows along Beacon Hill in Boston. Larger quantities yield an amethyst purple to a dark red coloration. Manganese glasses are usually transparent to infra-red radiation.

NATRIUM (Na) another of the fundamental glassmaking elements known as soda is discussed in detail elsewhere.

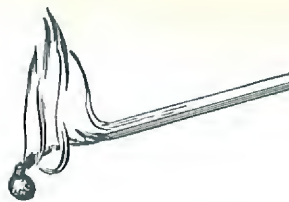
NEODYMIUM (Nd) is one of the rare earth elements. As the oxide, Nd_2O_3 , it is used in special opthalmic glasses to absorb certain portions of the spectrum. Very small quantities may be used as a decolorizer for iron. Praseodymium is also usually present, and as noted before, these two elements combined are known as didymium. These rare earth metals are found in Norway, United States, Brazil, India, and Australia.

NICKEL (Ni) in the form of nickel oxide, NiO , is used as a coloring agent. It produces a reddish brown color in soda lime glasses and a violet color in potash lime glasses. It is used with cobalt to yield a neutral tint glass. The greater portion of the nickel used in glassmaking is derived from Canada.

NITROGEN (N) is used in glassmaking in the form of nitrates, to act as oxidizing agents by the release of oxygen and dissipation of the nitrogen. No nitrogen actually remains in the glass as a constituent of the glass. Sodium nitrate, which is obtained in Chile and Peru, or which is made synthetically by chemical companies, is the usual form in which nitrogen enters the glass melt.

OXYGEN (O) is introduced as an essential component of all glassmaking materials, and remains as an actual chemical component of the glass body. It is never introduced separately, but always as the oxide or other salt of the other component elements.

PHOSPHORUS (P) usually introduced as the pentoxide, P_2O_5 , acts as an opacifier or opalizer in soda lime or potash lime glasses. When totally substituted for silica, it forms a series of



so-called glasses of scientific, optical and opthalmic interest. Phosphorus is found widely scattered throughout the world in the form of phosphate rock, in South Carolina, Canada, and Spain, and may also be obtained from bone ash and other similar materials. In glassmaking it is usually used in the form of aluminum metaphosphate, which is prepared by various chemical manufacturing companies throughout the country.

POTASSIUM (K) — Potassium oxide, like sodium oxide, is a flux. Substituting it for soda tends to produce more brilliant glasses with higher resistance to weathering. It increases the viscosity of the glass and lowers the index of refraction. Since it is more expensive than soda, its use is not nearly so general. Potassium oxide does not exist in nature but it is produced in the glass melt from the potassium salt used. Ordinarily this is potassium carbonate, which is found in the ashes of wood and plants and beet sugar residues, wool scourings, etc. The largest quantity is derived from potassium chloride by processes analogous to those used for producing the corresponding sodium salt.

PRASEODYMIUM (Pr) is another one of the rare earth group of metals, and always is found associated with neodymium. It is used in special opthalmic glasses to absorb certain portions of the spectrum.

SELENIUM (Se) which is principally found in Germany and Canada, is used as a colorant. It yields a pink color when used alone and a deep ruby when used in conjunction with cadmium sulphide. In small percentages it is used as a decolorizer, sometimes in conjunction with cobalt.

SILICON (Si)—The fundamental glassmaking element introduced as silica or sand. Already presented in detail.

SILVER (Ag) in the form of one of its salts, is used to a small extent to produce a yellow color in the glass. It is present in the glass as the colloidal metal.

STRONTIUM (Sr) in the form of strontium oxide, SrO , acts as a base, and may be substituted either for lime or barium. It is quite expensive, and is seldom used.

SULPHUR (S) acts as a reducing agent. When present in the glass in the form of sodium sulphide, Na_2S , it yields a yellow color. It is usually

introduced into the glass in the form of salt cake, sodium sulphate.

TIN (Sn) is usually introduced into the batch in the form of stannous oxide, SnO . In conjunction with fluorides and phosphates it enhances opalescence. In ordinary soda lime glasses it acts to chemically reduce the iron and in certain special glasses acts to increase the ultra-violet transmission. In copper or gold ruby glasses it improves the color of the ruby. Tin, in the form of stannous oxide, is obtained from the Straits Settlements, Malay Peninsula.

TITANIUM (Ti) is quite similar to aluminum and is usually introduced in the form of TiO_2 . Although it may be substituted either for the lime or the silica, this is seldom done, but it is used more often as a colorant. In the form of TiO_2 under certain conditions it will yield a violet color. In conjunction with iron or cerium, titanium produces a yellow color.

URANIUM (U), usually obtained from the Belgian Congo in the form of sodium uranate, Na_2UO_4 , produces a greenish yellow, fluorescent color in glass. It is used only in small percentages. It absorbs certain portions of the spectrum and is used in optical and ophthalmic and special scientific glasses.

VANADIUM (V) in the form of vanadium pentoxide, V_2O_5 , produces a green color. Since it absorbs certain portions of the spectrum, it is used to some extent in ophthalmic glasses.

ZINC (Zn) in the form of zinc oxide, ZnO , acts as a base and may be substituted for calcium oxide. It is not quite so good a flux as calcium oxide. It increases the resistance to weathering and decreases the coefficient of expansion. It is said to increase the ultra-violet transmission. It is obtained as a by-product in the refining of lead to some extent, but is also directly obtained from the natural zinc ores. Zinc is found widely scattered through the United States, in New Jersey, New York, Virginia, Tennessee, Missouri, Kansas, Oklahoma, and farther west.

ZIRCONIUM (Zr) is used very slightly. It tends to increase viscosity and the refractive index. It is sometimes used to improve the weathering resistance. It is introduced into the glass in the form of zirconium oxide, ZrO_2 .

These are the 41 chemical elements from A to Z, that enter into the composition of glass. An imposing array of almost 50% of the total number of known elements. Their compounding is a most exacting science, involving both the purity and

proportion of the component elements. With the exception of those materials that are volatile or combustible, every substance that enters the batch is present in the finished product.

Glass must be surpassingly free from any defects, such as included gases or other extraneous materials because of its revealing nature. Transparency is but one of the properties of glass. A unique combination of other properties, whose behavior in glass is contrary to general experience, confuses any attempt to give this material a simple, concise definition.

In a general way everyone has some idea of what glass is. It is a material resulting from the fusing and subsequent cooling of a mixture of chemical substances. In its most useful condition, glass is a clear, transparent-solid, which is extremely hard, and highly resistant to scratching and wear. Almost all hard materials are brittle and glass is no exception. When glass breaks, the edges of the fragments are sharp. Solid glass is an entirely amorphous, noncrystalline material which always breaks with a shell-like or "conehoidal" fracture. It has no grain and since there are no definite lines of cleavage in glass, it exhibits the unique property of snapping along a score or cut in the surface.

Because glass contains large proportions of silica, and is produced by the action of heat upon that silica, it is generally classed among the ceramic materials. However, glass stands in a class by itself, quite distinct from other ceramics. Most other ceramic materials are shaped cold, and then fired to produce the desired result. Glass, on the other hand, is shaped at extremely elevated temperatures and then allowed to cool. However, it may again be made semi-plastic, plastic, or even molten, by the further application of heat, and in either of these conditions may be distorted, or molded to shape with greater or lesser ease. For this reason, glass is also considered as a thermoplastic material. It has no definite molecular structure although each of its components is bonded to its neighbor in a definite relationship.

In the molten state, glass is a mutual solution of several different discrete chemical compounds. These compounds become so thoroughly intermingled in the founding process as to become chemically bonded one to another. If cooled slowly from the liquid state, or if held too long in the plastic or semi-plastic condition, the various chemical compounds tend to crystallize out of the solution. When this occurs the glass is said to be

devitrified. Actually the glass has frozen just as ice freezes. This condition is avoided by carrying it through the crystallizing temperature so quickly that it becomes solid as a super-cooled liquid, and the crystals are prevented from forming by the excessively high viscosity of the solid material at ordinary temperature.

Thus, glass is a solid super-cooled liquid ceramic material, which exhibits many of the properties of a thermo-plastic material which may be processed, cut, or fabricated to any desired shape. No simple definition can adequately describe glass, yet a mere mention of its name calls to mind its common characteristics and its utility.



These are the ingredients from which glass is made, dug up from the earth of which they are a part. These are the processes of transformation as they are melted in great furnaces; to be worked over by many machines, and by many men and women. To these material ingredients must be added those corporate substances—reputation, prestige, integrity, stability, leadership—which characterize the Pittsburgh Plate Glass Company. This . . . is the composition of Pittsburgh Glass.

SECTION "B"

BASIC GLASS PRODUCTS

B-1

POLISHED PLATE GLASS . . MANUFACTURE AND DESCRIPTION

B-2

CARRARA STRUCTURAL GLASS . . MANUFACTURE AND DESCRIPTION

B-3

PENNVERNON SHEET GLASS . . MANUFACTURE AND DESCRIPTION

B-4

PITTSBURGH LIGHTING GLASSES

B-1

MAKING PLATE GLASS



Mechanization at the casting end of a tank furnace. Here the molten liquid is quickly converted into a continuous ribbon of glass between the rolls of a massive machine.

The manufacture of Polished Plate Glass was the original purpose of the Pittsburgh Plate Glass Company, and has continued to be its principal business

The methods employed in its manufacture have been steadily improved and refined during its 60 odd years of glassmaking experience, and are by now almost entirely mechanized.

DURING this period, the elapsed time, from starting to mix the batch to the finished ground and polished plate, has been reduced from 190 hours to 15 hours. This has been accomplished by improved melting techniques, particularly by the continuous melting process; improved casting methods whereby much flatter, more uniform thickness glass is produced; conversion from annealing ovens which originally consumed 5 days to yield only more or less satisfactorily annealed glass, through the improved rod lehr which itself effected a magnificent saving, to the modern roller lehr in which wholly satisfactory annealing is accomplished in just 60 minutes; and the development of the continuous straight-away grinding and polishing method which has completely supplanted the "round table" methods and has reduced the time for completely grinding and polishing plate glass from 24 hours to only 4 hours.

By greatly increasing daily production, this

mechanization of plate glass manufacture has consistently decreased production costs and made possible lower selling prices. Although the older process has been largely supplanted, some of its features persist in the modern version because they continue to adequately serve their proper purpose, particularly for the production of "Jumbo" sizes.

Mechanical improvement, control of raw materials, and chemical research (which has played an increasingly important part), have been responsible for the development of the product. The flatness of modern rough glass permits finishing of $\frac{1}{4}$ inch thick glass from a blank only $\frac{5}{16}$ inch thick, whereas in the older methods the glass had to be cast at least $\frac{1}{2}$ inch thick to insure satisfactory finish on $\frac{1}{4}$ inch plate; the round tables of the old grinders and polishers never produced truly parallel glass surfaces, while present production will show faces which are parallel within a few



Creighton, Pennsylvania, Works No. 1, modern plant and laboratories. In this half mile long factory, plate glass for laminated safety plate glass is produced.

thousandths of an inch on a full size ground and polished plate.

The achievement and maintenance of a high and consistent standard of quality involves innumerable difficulties. Every step in the manufacture of plate glass is fraught with danger of ruining the product. There is hardly a moment during the process when a crisis may not occur. Any irregularities in cooling, may and occasionally do, produce an internal stress sufficient to shatter an entire plate. Even a brief lapse in the performance of any part of the complicated machinery would be disastrous.

To guard against such an occurrence auxiliary equipment of every description is constantly in reserve. In addition to maintaining a universal machine shop and foundry known as Shop No. 2 at Ford City, Pennsylvania, where much of the mechanical equipment is cast and fabricated, there is a fully equipped and staffed modern machine shop within each of the factories. They handle the plant maintenance, make necessary emergency repairs and replacements, without undue loss of time.

Two basic methods are employed in the preliminary stage of plate glassmaking; the pot casting method is the older, and used primarily for

making larger sizes and heavier thicknesses in comparatively small quantities; the continuous ribbon rolling method is employed generally for mass production of plate glass in smaller sizes and thicknesses; the finishing process and equipment is essentially the same in both instances.

The plate glass manufacturing facilities of the Pittsburgh Plate Glass Company are today concentrated at three points; namely, Creighton, Pennsylvania; Ford City, Pennsylvania; and Crystal City, Missouri. Its four large modern factories (2 at Ford City) have an unequaled capacity and produce in sufficient volume to maintain its position as the world's largest manufacturer of plate glass.

In addition, for many years, the Company has maintained a plate glass factory at Courcelles, Belgium, whose operation has twice been interrupted; first during World War I when it was essentially destroyed, and again during World War II when operations were suspended. The ownership of this factory enabled the Company to keep in close contact with Continental European glass manufacturing practice.

Works No. 1 at Creighton, Pennsylvania, the Company's first glass factory, went into production in 1883 with two 20-pot furnaces and, except for



A pot furnace door opened shows the pots bathed in flame. 2800 degrees plus—precisely timed—is required with the skill of the glassmaker to make glass.

adding one 20-pot furnace in 1907 and increasing the size of the pots, this capacity remained unchanged for 40 years. This plant was several times rebuilt and modernized, but always on the site of the original factory. It was the first factory to produce polished plate glass on a straight-away and semi-continuous production schedule, both as regards the glassmaking and the grinding and polishing. The first unit consisting of a melting tank, a grinding shed and polishing shop with the necessary warerooms and appurtenances, was completed in 1924 and was expected to produce about 6 million square feet of $\frac{1}{4}$ inch thick polished plate glass for a 300 day year. However, the initial operation of this first unit so far exceeded expectations that when the second tank and grinding and polishing units were completed in 1926 the annual capacity of the plant was found to be approximately 45 million square feet of $\frac{1}{4}$ inch polished plate. There are now 3 tanks at Creighton, only 2 of which are used at any one time.

The Creighton factory has been converted almost wholly to the production of $\frac{7}{16}$ inch thick polished plate glass for laminating. It was the first plant to produce laminated safety glass and is equipped to produce Herculite and bent glass.

Works No. 4 at Ford City, Pennsylvania, was

first built in 1890 and was then equipped with the newest type grinding and polishing machinery. The new grinding and polishing tables were not only much larger, 36 feet in diameter, but the huge cast-iron table bed could be lifted from the fixed vertical drive shaft on which it revolved and which formed its supporting base. Thus the table could be pulled from under the grinding runners and transferred to the polishing machines, similarly operated, permitting a completely finished operation on one side before removing and turning the glass for the second side operation.

Fires and floods several times damaged the plant which on being rebuilt was modernized and expanded to absorb the immediately adjoining Works No. 3, originally built in 1887. A continuous grinding and polishing system, similar to the one at Creighton, was installed in 1929, and in 1940, six of the old pot furnaces were removed and a new continuous tank with a daily capacity of 150 tons was put into operation.

Works No. 4 now has two types of possible glass manufacture, both the pot and continuous tank processes, with a combined annual capacity of approximately 35 million square feet of $\frac{1}{4}$ inch thick polished plate glass. In addition, it also produces $\frac{1}{8}$ inch Vista plate glass, Crystalex plate



A sea of frozen glass. Here a furnace is down for cold repairs. The workman uses an air hammer to break up the aquamarine mass. After repairs, the tank is lighted and the glass melts again.

glass, Water White plate glass, Blue plate glass, Flesh Tinted plate glass, $\frac{1}{8}$ inch and $\frac{1}{4}$ inch Solex and Enameled glass products. It has a modern assembly line mirror plant as well as extensive facilities for bending and tempering.

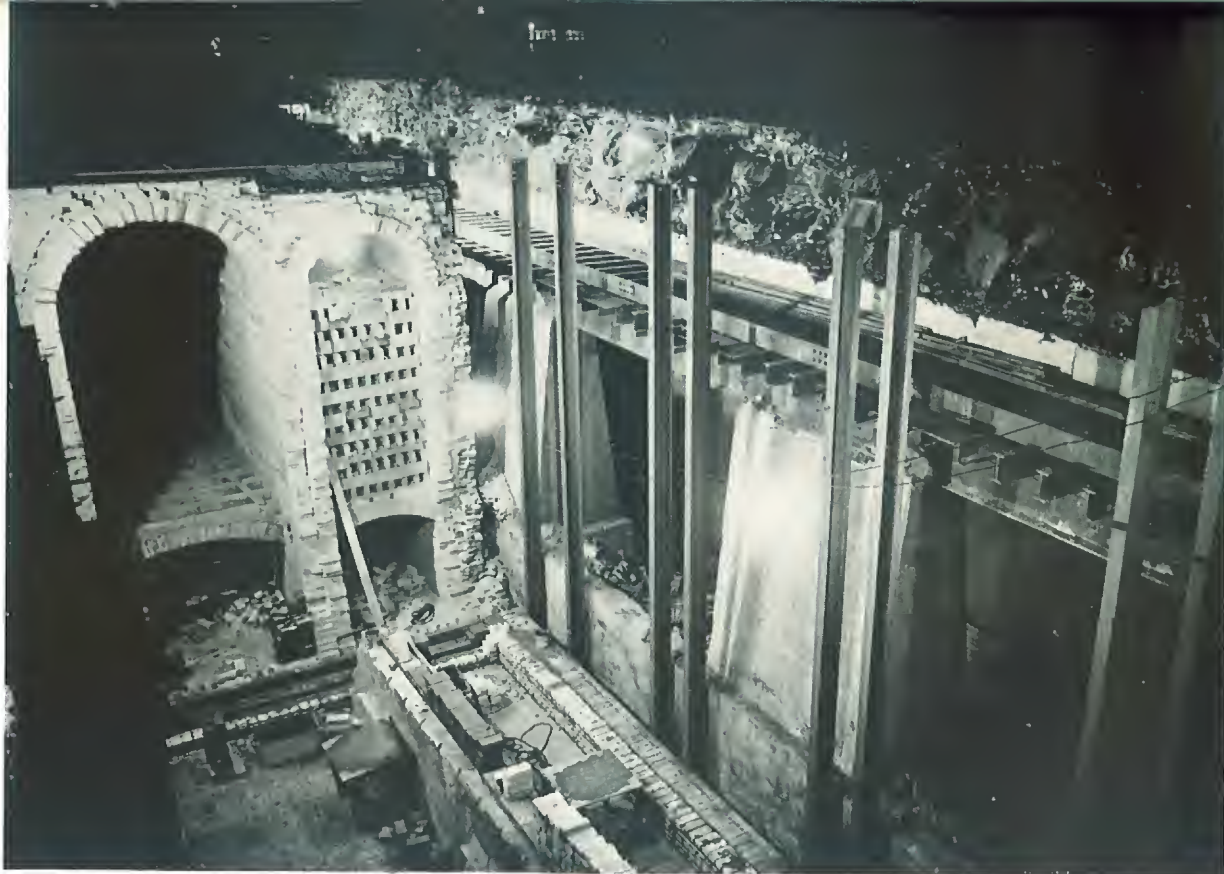
Works No. 6 is also located at Ford City, Pennsylvania, about a mile and a half above Works No. 4. This was the site on which old Works No. 5 had operated. Works No. 5 had been primarily designed as a quality or "silver" plant producing $\frac{3}{16}$ inch polished plate glass, most of which was used for mirrors. During the final stage of its existence 1920-1930 it was considered a small capacity, small-size plate glass plant. It employed eleven 20-pot furnaces; water-cooled cast-iron flat casting table, and water-cooled cast-iron roll, pulled across the table on thickness trams to form the plate. When in 1930, the Company decided to build a modern structural and optical glass plant to take the place of the 40 year old Works No. 6 then located at Charleroi, Pennsylvania, this was the spot selected.

Works No. 6, as it exists today, is a modern plant of infinite variety and might properly be designated as a special products factory. It produces heavy plate glass $\frac{3}{8}$ inch thick and greater, Carrara Structural Glass, optical and ophthalmic glass, and some 80 special glasses, all of which, because

of their special nature, are best produced by the pot method. Its pot furnaces are of varying capacities. Casting equipment is the same as at Works No. 4; the grinding and polishing equipment is of the same general character as that at Works No. 1, at Creighton.

The fabricating and decorating department at Works No. 6 is perhaps the most interesting and certainly the most active division of the plant. Nearly every process used in the art of decorating glass is practiced in this shop and many are proceeding simultaneously. The department handles special fabrication of a very wide variety of Works No. 6 products, including Carrara, as well as some glass from other factories. Some of the processes used are peculiar to Works No. 6, and all of them are described in Section F. The department occupies an immense room with special equipment for edge finishing, special surfacing, sandblasting, laminating, heat treating, beveling, etc.:—grinding wheels, sanding belts, polishing wheels, sand grader and circular grinder tables—a beehive of activity affording a vivid picture of the wide variety of uses to which glass may be adapted. Normally, the shop is engaged chiefly in the fabrication of Carrara products.

In addition, Works No. 6 processes a large part of the Company's production of Herculite; fabri-



A modern glass tank or furnace resembles more than anything the maze of checkers, passages, etc. of a modern open hearth furnace. Tanks require months to build and the one pictured contains over 1000 tons of refractories to hold 1500 tons of glass.

icates Herculite doors, portlights, and miscellaneous structural glass units; assembles glass tanks. Here, too, is done most of the glass decorating either by sandblasting or otherwise cutting, and the sculpturing of glass murals. Glass plaques, signs, dial glasses, and a vast number of special products both large and small are produced here.

Works No. 9 is located at Crystal City, Missouri, about 30 miles south of St. Louis on the Mississippi River where there has been a glass factory on this site ever since 1879 although it was never operated on a successful basis until acquired by the Company in 1895. This factory is unique in that all of the sand used in the plant, both for the making of glass and for the grinding of the rough product is mined from a hill directly back of the plant. Like the others, Works No. 9 has also been rebuilt and modernized, and in virtually all respects is almost a counterpart of Works No. 4. Works No. 9 also produces a considerable portion of the laminated safety glass which the Company manufactures. It has electric furnaces for tempering glass and facilities for bending glass. Its productive capacity is 35 million square feet of plate glass annually.

Under the direction of the General Manager of Plate Glass Factories each of these plants is managed by a superintendent, with a staff of assistant

*See Page 10 et sequa.

superintendents who supervise each of the major departments of the factory, i. e., Casting Hall, Grinding and Polishing Shed, and Wareroom. The various subdivisions of each department as identified on the flow chart* of the manufacturing process are in charge of capable foremen.

Among the preliminary operations which the chart does not embrace is the preheating of clay work in auxiliary furnaces known as pot arches.

The actual plate glassmaking operation begins with the assembly of raw materials. These arrive at the various factories in railway freight cars and are spotted alongside the silo-like cylindrical storage bins which comprise the batch house. Modern electric shovels are used to remove the materials which are carried directly from the car to the top of the batch house on belt type elevating bucket conveyors. Each material is deposited in one of the huge, special, separate storage bins, each having a capacity of about 1,500 tons. These bins are cone shaped at the bottom through which the material is drawn, each ingredient being carefully weighed either into a batch mixing car or into a hopper from which it may be dumped into the batch mixer. Every precaution is taken to see that proportions of materials are very precisely adhered to and to avoid any deviation from the prescribed batch weight and content. In the final mix, cullet



Glass in repose—a nightmarish dream of contorted transparent mass and shapes. At the base is the refractory floor of the tank.

(broken plate glass of the same composition, which has been crushed) is weighed into the mixture to equal approximately one-third of the raw batch, so that the mix finally consists of 25 per cent cullet and 75 per cent raw materials, made up of about 72 per cent sand, 13.5 per cent lime, 12.5 per cent soda of which the major portion is soda ash and a smaller amount is salt cake, and minor amounts of other ingredients.

Since the cullet contains the same ingredients as the present batch, its remelting facilitates the amalgamation of all of the raw materials into the new metal, which is the purpose of its introduction in such large proportion.

Batch mixing is, of course, an intermittent operation, essentially. However, since tank operation is continuous, 24 hours a day, 7 days a week, the batch mixers must work continuously to keep the tank supplied with material for melting. Where the glass is being melted in tanks, the batch is carried from the batch house to the filling position at the melting end of the tank furnace by a bucket monorail system. These buckets are filled at the mixer discharge and have a capacity of approximately one ton. This method of handling eliminates the hazard of unmixing the batch, which could detrimentally affect the glass quality.

Glass melting tanks have an appearance somewhat like a miniature modern airport hangar with crowned dome and straight side walls. In construction and actual melting operations they very closely resemble the open-hearth furnaces of a steel mill. They are built entirely of refractory materials which are held together by the pressure of steel buckstays and tie rods almost entirely without the benefit of mortar of any kind. The refractory materials used are specially compounded so that any solution which may occur as the result of action of glass batch shall be at a minimum and as nearly uniform over the block area as may be possible. The blocks used for side walls of the basin are prepared by melting the ingredients in an electric furnace and casting into the desired shapes. All blocks used are extremely refractory and go into solution in the glass only very slowly, so that there is a minimum absorption of the refractory materials by the glass. Refractory blocks are usually 12 inches thick and vary from 18 inches to 36 inches wide by 36 inches to 48 inches in length.

These blocks form the floor and side walls of the glass melting tank basin and are simply set as closely together as possible, the cracks being left open. The superstructure of the tank furnace which encloses the heating area is laid up in silica



Conveyors for coal for fuel—Bins for batch material—Batch sand-drying equipment, all a maze of movement—the crawl of the glass plant.

brick. Its crown arch and side walls are supported above the refractory block tank walls. Along each side of the upper walls in the melting end of the tank are a series of ports through which is fed the mixture of gas and air that is burned to melt the batch. Connecting masonry flues permit the extremely hot gases from the tank to flow through checker chambers which are lined with heat-absorbing fire clay brick. A valve at the point where flues from both sides of the tank converge, controls the direction of flow so that the fires may be alternated from one side of the tank to the other at periodic intervals.

The melting of glass is a continuous operation from the time the fires are lighted until they are extinguished at the end of a "campaign" which may be as much as 18 months or 2 years. The length of a campaign is determined by the

amount of wear and tear on the side wall blocks of the tanks. The fluxing materials in the glass batch which help to dissolve the silica sand are also effective in dissolving the refractory walls of the basin and since these fluxes are most active at the surface of the glass where the temperature is highest the corrosion of the walls is progressively greater from the bottom upward. Repairs of the upper walls may be made from time to time, with almost full heat, but when the lower courses of blocks become so bad that a general repair is required, the tank is very nearly drained of glass and the fires turned off.

When so-called hot repairs *are* made, the refractory replacements are removed from the adjoining pot arch furnaces where they have been pre-heated to glass furnace temperature and the replacement is made at nearly full heat.



The batch house interior occupies the island position on the flow chart below. The buckets pass below the bins in a trolley system to pick up their charge. The charge is automatically and rapidly weighed. Buckets go to the charging doghouse of the tank.

Usually the tank bottom will remain good for a considerable number of campaigns before needing to be rebuilt.

In the tri-lateral presentation of the continuous tank method of plate glass manufacture, it is possible to emphasize only those operational features directly involved in the process of transforming raw materials into finished plate glass products. Later, the pot method of manufacture will be presented to the extent that it differs from the continuous tank method.

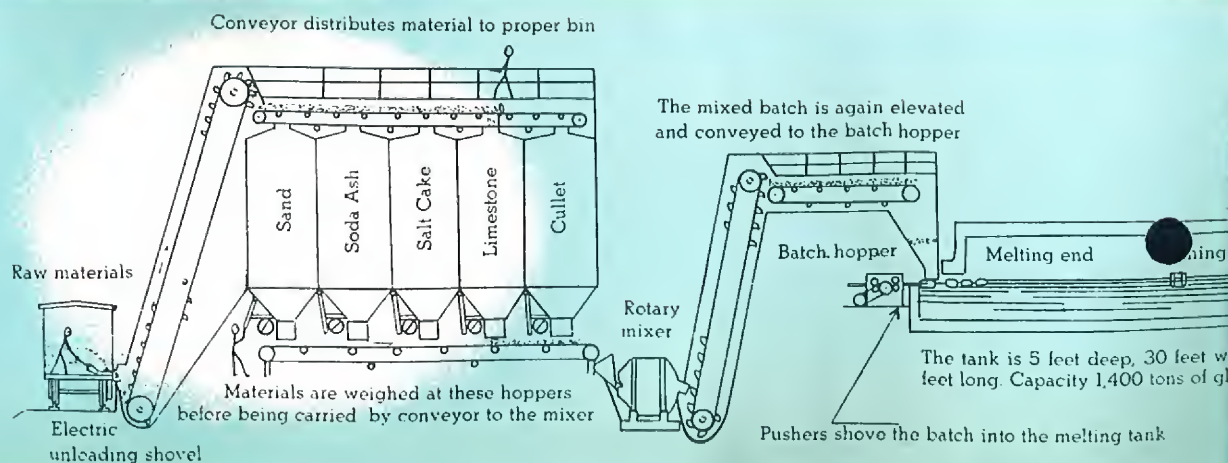
When the fires are first lighted at the beginning of a campaign the temperature of the tank is elevated gradually over a period of about three weeks until all of the tank and furnace lining materials become thoroughly heat soaked and its contents melted. The mixed batch of raw materials is then fed almost continuously into the melting end of the tank, called the filling doghouse, and is pushed automatically into the roaring interior of the white hot tank where temperatures range from 2830°F. to 2865°F., and higher.

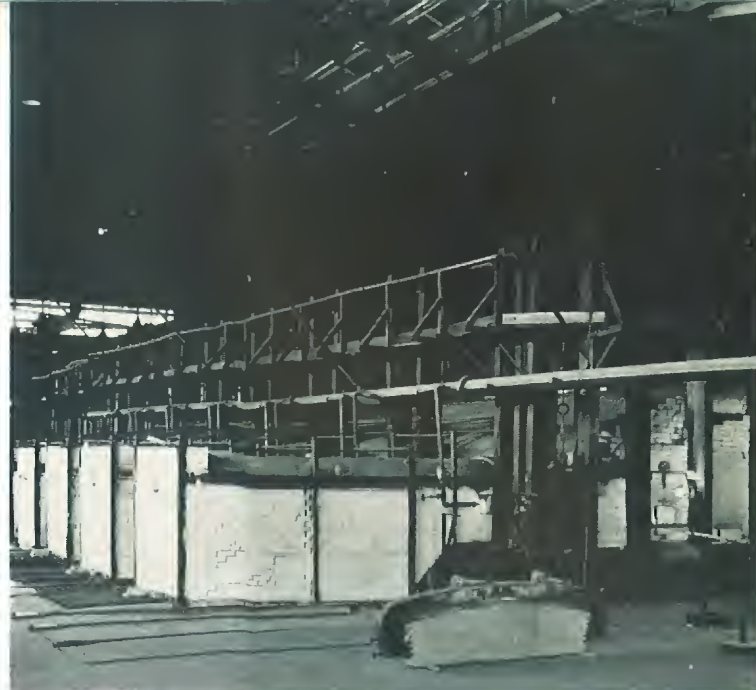
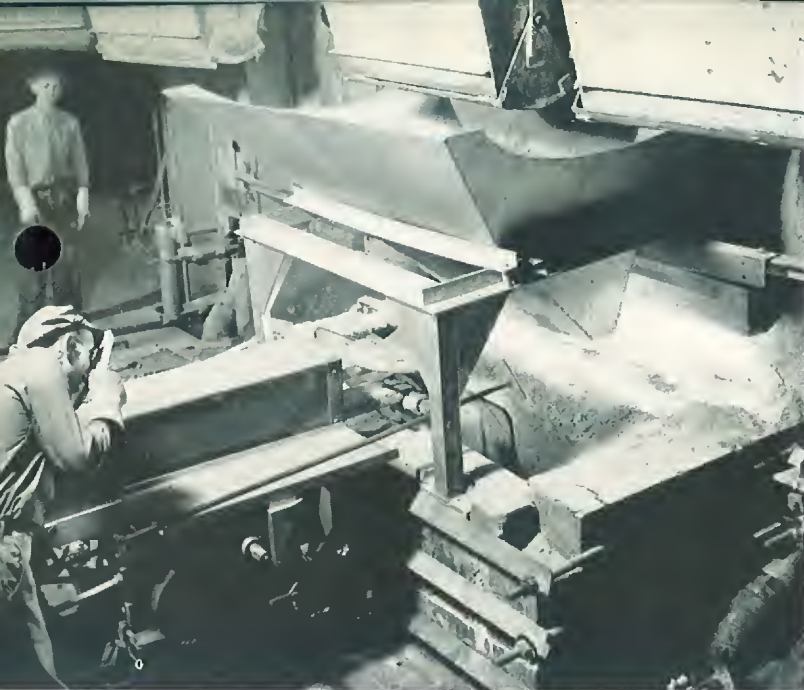
Melting is accomplished almost entirely by sur-

face heat, the flaming gas spouting from the side wall ports, first from one side and then from the other, being reversed periodically. The crown of the furnace radiates directly down into the glass batch and the fires tend both to heat the crown and the surface of the glass batch. The batch is very much lighter than the molten glass and floats on the surface, either in large lumps, where intermittent feeding is practiced, or as a blanket over the whole melting area.

By common consent the area of the molten glass is arbitrarily divided into the melting zone, the fining zone, and the working zone. No actual demarcation exists between these areas, except as temperature differences exist. In the melting zone, the lumps of batch float in a mass of foam produced by their own melting and the mass of boiling glass about and below them. The foaming is most violent about half way through the melting zone, where the temperatures are highest. The lumps are moved about by hand-operated hooks to keep the largest (least melted) ones near the hotter part of the fires, and as they melt, they

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The charger pushes the cold dry batch of raw materials into the tank opening whence it is gradually absorbed by the already molten glass and becomes more glass. Elaborate masonry is under the floor line of the tank.

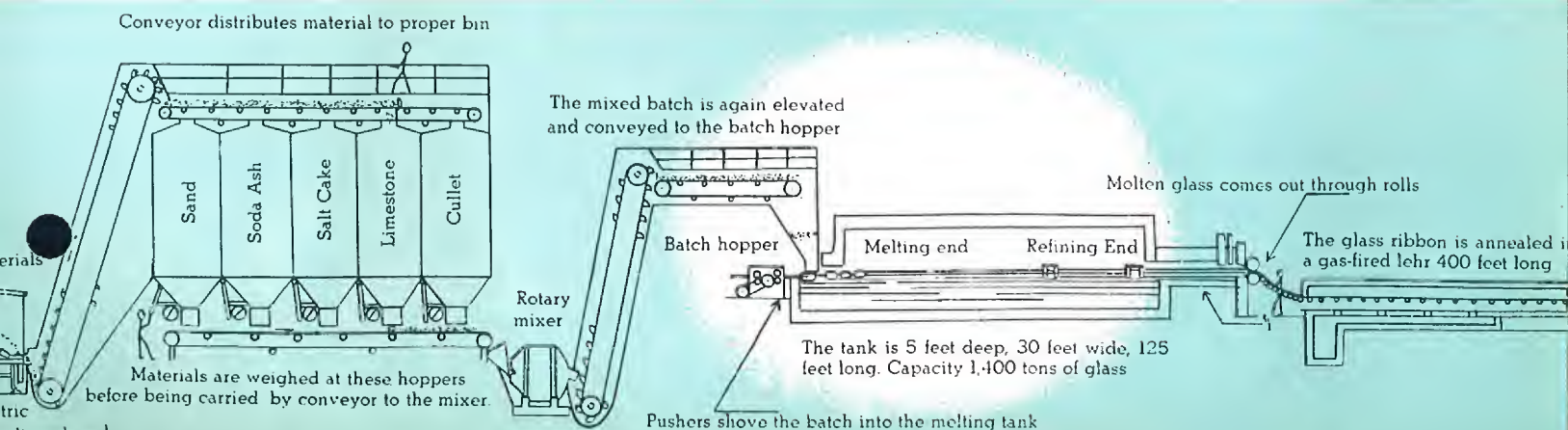
become smaller, and move slowly down the furnace. By the time they come opposite the fourth port, they are really only a mass of foam or froth. The fires from the fifth—and if necessary sixth—port are hot enough to reduce the viscosity of the molten mass to a point where the foam bubbles burst easily and rapidly, and thereby a foam line is established beyond which no foam is apparent.

Here begins the fining zone, where the glass is quiescent and any small bubbles of gas within the glass have an opportunity to rise to the surface and burst. In some respects this process is much the same as the gathering of cream on a pan of milk. Since no heat is introduced into the furnace in the fining zone, all the heat available must come from the metal itself and from some radiation from the melting zone. Consequently, the temperature of the glass falls steadily and progressively as it moves toward the working zone. Even when no glass is being drawn from the tank, there is a constant flow of glass from the melting zone to the working zone, on the surface, and in the reverse direction, along the bottom. Also the glass

flows toward the side walls on the surface and toward the center, along the bottom. These convection currents tend to carry dross to the side walls, and thence back into the melting zone, where ultimately the dross is finally melted and assimilated into the glass. Tests have indicated that it requires about 8 hours from the time raw batch is filled into the filling end until it is rolled out as a sheet of rough plate glass at the working end of the tank, which it leaves at about 2100°F.

At this point the molten glass is fed by gravity between a pair of heavy, cast-iron, water-cooled rolls, which are adjustable, vertically, to determine the thickness of the sheet. These rolls are set very close against the delivery lip of the tank, so that the glass is forced into the pinch of the rolls and thus squeezed to the desired thickness for the ribbon. This is possible only because the high viscosity of the glass permits it to jump the gap between the lip and the rolls without sagging. As it passes from the water-cooled forming rolls, the surfaces have become sufficiently

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The observer looks through a port with a pyrometer. In the flow chart below, the length of the tank is shortened for convenience. A sample is taken from the tank—and for the same purpose as one does in making molasses taffy.

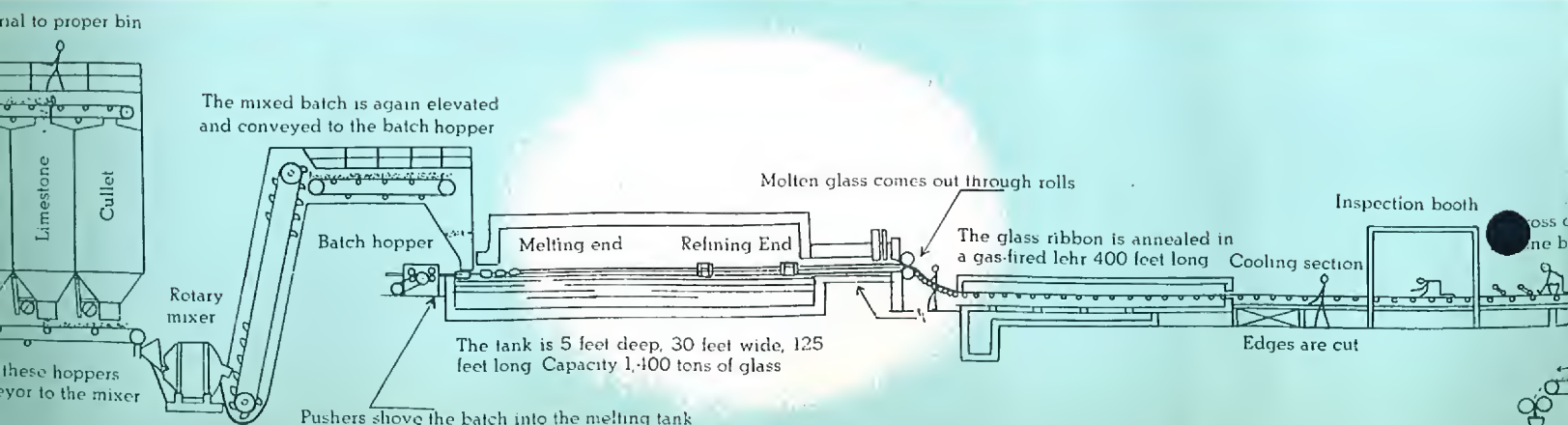
chilled to form a more or less self-sustaining sheet or ribbon, even though the body of the glass is still very hot.

The formed sheet is picked up on the smaller apron rolls, which are actually a part of the annealing lehr mechanism, but are not enclosed as is the rest of the lehr. Consequently, in this area, the glass loses heat rapidly, and the temperature falls from about 1700°F. leaving the rolls to about 1500°F. entering the lehr. The lehr is essentially an open tunnel, in which graduated temperatures are maintained by means of gas fires. These fires are adjusted so that the glass cools very rapidly from 1500°F. to 1150°F.; very slowly from 1150°F. to 950°F.; and again rapidly to room temperature. The slow change from 1150°F. to 950°F. is known as the annealing range. In this range the temperatures of the surfaces and the body of the glass are equalized while the glass is still sufficiently soft to permit the structural re-adjustment necessary to relieve the heavy chill strains introduced into the glass as the sheet is formed. Unless these strains are relieved, the glass would be left in an unstable condition and would

break into pieces after it became cool. After the glass has cooled to 950°F., no further adjustments of strain can take place, and any further strains which may be introduced into the glass by rapid cooling to room temperature are temporary and relieve themselves as the temperature of the sheet becomes uniform. The glass leaves the end of the lehr at about 400°F. and enters the cooling section, where the surrounding air has free access to the glass and rapidly reduces the temperature so that in the inspection booth the inspectors may crawl about on the glass without great discomfort.

In the inspection booth under strong lights at the edges of the ribbon, the glass is very carefully examined for any extraneous inclusions, such as stones or ream. Stones may result from small particles of batch which somehow have come through the furnace unmelted or from small particles of clay or silica spalled from the furnace structure, or even drops of molten material which have fallen into the glass from the furnace superstructure and have not been assimilated into the glass mass. Ream may result from the residuum of a stone or drop which has itself dis-

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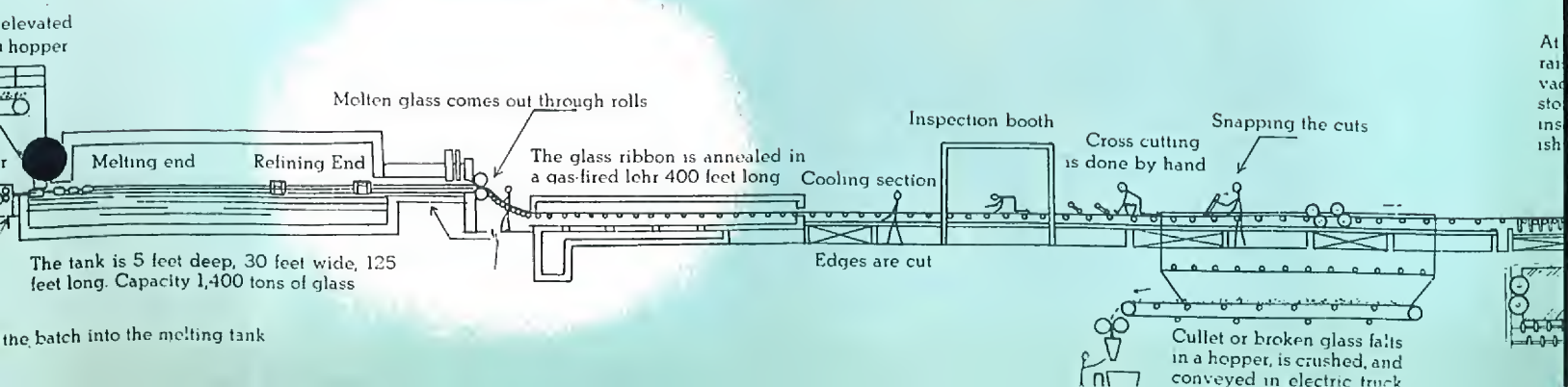
Still white hot but sufficiently chilled to retain the shape imparted by the forming rolls, the ribbon of glass flows smoothly into the annealing lehr.

appeared, having a tail like a comet tail. It may also result from incomplete assimilation of completely molten batch which for some reason has not reached the full temperature of the bath or has failed to be stirred into the melt either by the convection currents in the glass or by actual stirring. Stones and seed or blisters can be found in the examining booth and marked, while ream can seldom be found in rough glass except by examination of the edge. The examiner marks up the sheet to indicate where it must be cut to eliminate inclusions which might cause breakage in the grinders and polishers. In some factories it is customary to save only full size plates—plates which will exactly fit the deck of the grinding and polishing tables—while smaller glass is broken up into cullet. In others, matched sets are laid in the grinders and polishers, and in these factories it is customary to cut adjacent parts of the ribbon so that, when laid together, they will fit the deck. Glasses which are too small to cover at least a quarter of the deck area are seldom saved, and never, if less than the full width of the deck. The edges of the ribbon are cut mechanically while the

crosscuts are made by hand. The cutter uses either a standard cutting wheel or a block diamond cutter, as he prefers. He runs his cut across the ribbon as it moves along—and he himself moves on to the next cut. In its forward progress the glass passes over a roller which is a bit higher than those on either side, and as the cut mark reaches this roller, the cut snaps! The rollers just beyond the snapping roll move a tiny bit faster than the others, so the plate jumps forward an inch or so at the instant the snap occurs, thus avoiding chipping of the cut edge of the glass.

The snapping table or cutting table is at the end of the lehr conveyor system, and from this point the glass blanks are moved by vacuum frame-equipped crane directly to the grinder and polisher laying yard. Wherever possible, large glass is handled with these vacuum frames, instead of by hand. The cranes are individually equipped with their own vacuum pumps and tanks. The vacuum to be used is controlled by the operator of the crane according to the thickness of glass being handled. The vacuum cups are rubber-faced steel discs about ten inches in diameter and

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The annealing lehr is a maze of mechanical and heating equipment and is spotted by the white island on the flow chart below.

each frame is equipped with eight of these cups.

The cullet—strips of edge cut from the ribbon, and the pieces of glass unsuitable for laying in the grinders and polishers—are dumped from the snapping table into a cullet hopper, thence to a crusher, and ultimately back to the batch house, when, as previously noted, it is incorporated into the mixed batch, of which cullet forms about 25% of the mix.

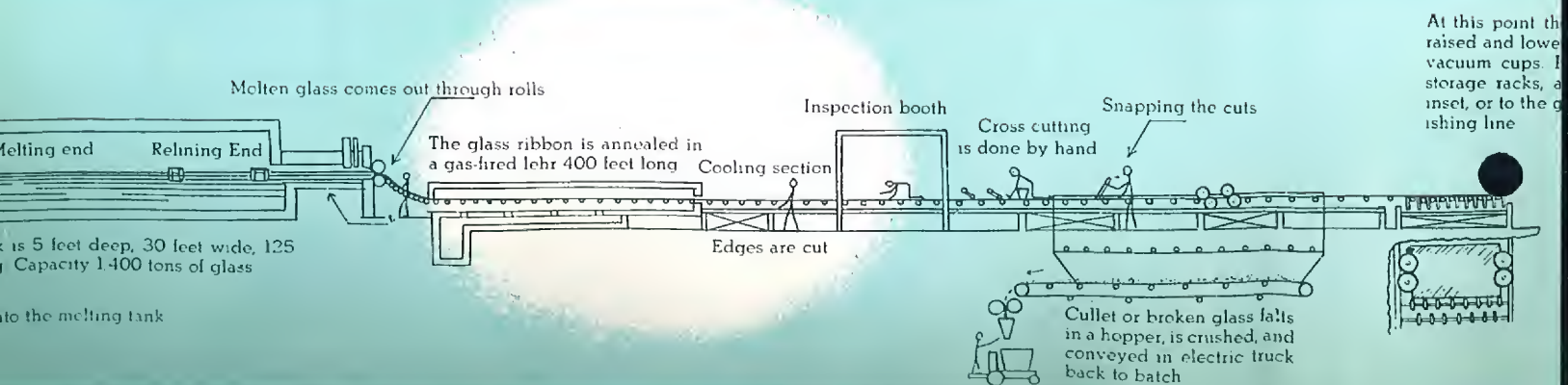
Ample provision is made in the casting hall for the storage of rough glass, which is always stored as full size plates. Initially, the glass is piled on portable "A" frames on edge, to a depth of 65 to 90 plates on a side, one plate directly against another. The plates are set on felt-covered wood blocks placed about 10 inches in from either end, at an angle of about 15° from the vertical. When fully loaded, these portable "A" frames are moved to the rough glass storage space and either stacked as they are, or the glass unloaded and piled similarly against permanently set storage racks. Frequently as much or more than 10,000,000 square feet of rough glass may be in storage at any of the various fac-

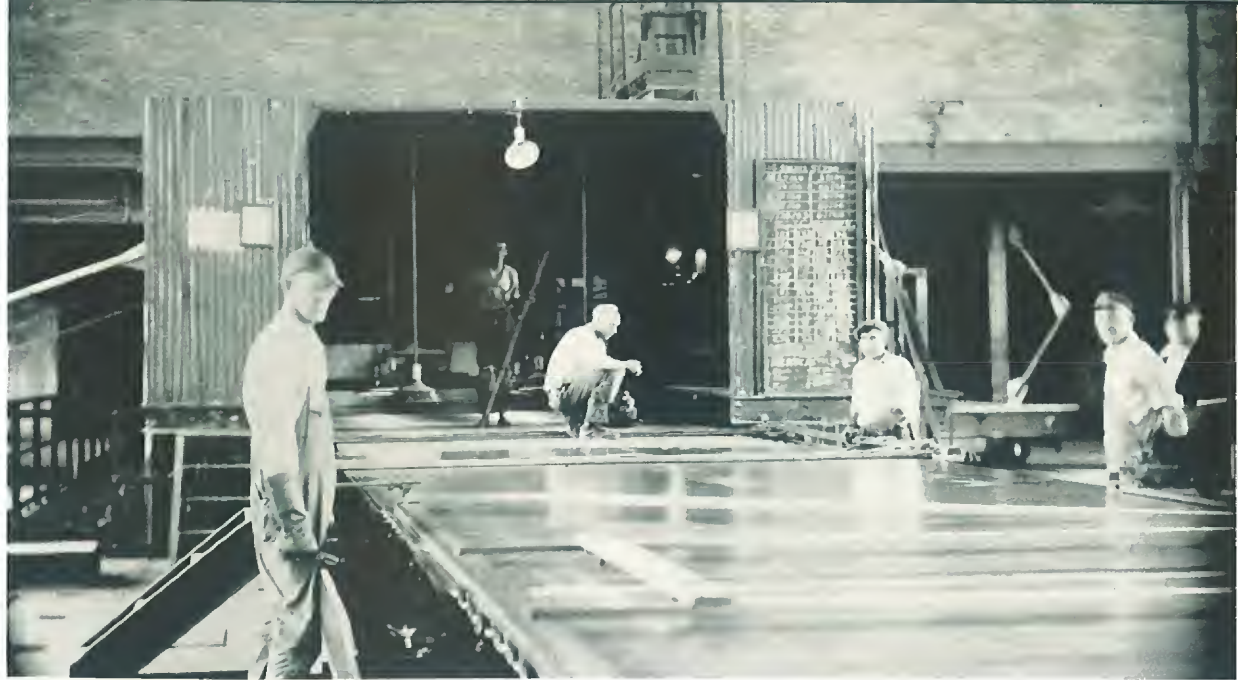
tories. This stock is built up to afford a steady supply of glass to the grinders and polishers during shut downs which may occur in the casting hall for one reason or another. It is accumulated over week-end shut downs in the grinders and polishers and by virtue of differences in the rate of production of rough glass, and its use in the grinders and polishers, which may amount to several plates per hour.

Except as just noted, when differential speeds or grinder and polisher shut downs prevent, the glass is moved directly from the snapping table to the laying yard of the grinders and polishers on a conveyor system. The conveyor extends into the grinding department area so that the vacuum cup-equipped hoists of the laying crane may easily pick up each glass blank as required and carry it to the upper end of the laying yard preparatory to laying it upon the grinder and polisher decks.

The grinders and polishers are housed in a building which is approximately 1,200 feet long from end to end. The tables are rectangular cars of cast iron which are coupled together to form

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The preliminary inspection booth, where imperfections are quickly spotted even though the surfaces of the glass are still rough.

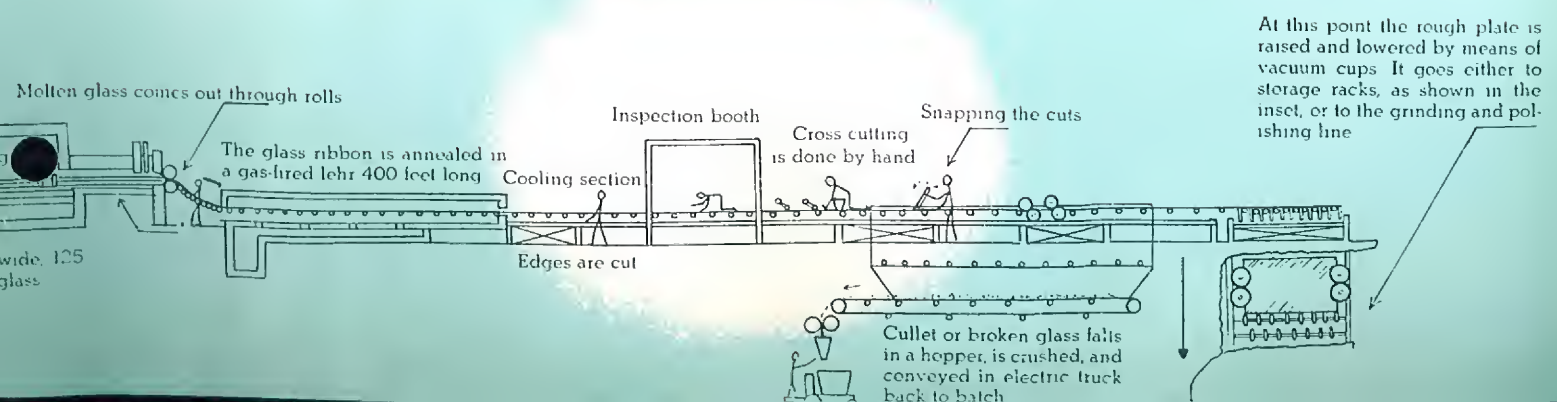
a continuous ribbon something more than 1,000 feet long, running on an especially built railway track, the level of which is maintained accurate to something better than .003 inch throughout its entire length. The tops of the tables, called decks, are ground perfectly true and flat and are maintained so by constant inspection and checking. Before any glass is *ever* laid on the tables, the whole line is subjected to the same grinding process as is subsequently used in grinding the glass—and at intervals this grinding of the decks to uniform flatness is repeated.

In the laying yard, the crane deposits the glass blank in a very thin bed of the finest plaster of Paris, which has been spread over the deck by hand. A set of rollers, carried also by the crane, moves forward over the glass, squeezing out surplus plaster and air from under the glass and ensuring that the glass is set securely against the deck. All along the two long edges of the table there are small holes drilled through the deck. Oak pegs are driven into these holes and the glass is stopped by small oak wedges jammed be-

tween the pegs and the glass. As the deck moves forward, the plaster hardens and by the time any given deck has come under the first grinder, the plaster has set up sufficiently so that the glass is firmly held.

Sand and emery, in water suspension, are used to grind the glass. The sand is obtained by dredging from the river bottom, or as in the case of Works No. 9 at Crystal City, by mining from a sand bank. All of the preliminary grinding is done with sand, while the finish grinding is accomplished by the use of emery, which is obtained generally from Turkey. As originally obtained, of course, the sand or emery is a conglomerate mixture of fine and coarse materials which must be separated from each other in various grades of fineness in order to obtain a uniformly level and smooth glass surface. This is accomplished by feeding the mixture of sand and water into the bottom of a cone shaped tank. Obviously, the velocity of the mixture changes rapidly in the conical section and very sharply at each successively higher outlet. In this manner clean separa-

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Vacuum cups replace hands and conveyor belts replace feet. Rough glass in storage and in transit to the grinding and polishing line.

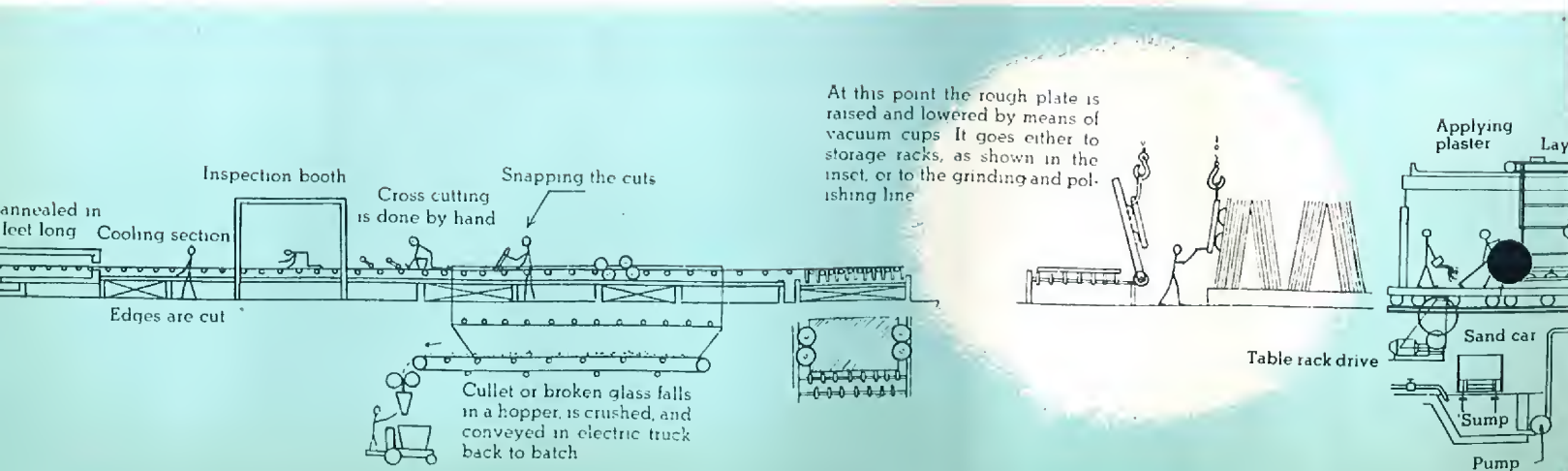
tions of various desired sands is accomplished and each grade is led to a particular grinder or group of grinders. Sand grading is a continuous operation from the time the grinder and polisher is started up Sunday midnight, until the week-end shut down at midnight, Saturday. The coarsest sand used is approximately .37 mm. in diameter, while the finest is approximately .027 mm. in diameter. A slurry of emery or other similar hard abrasive is fed only to the last few grinders, the first grain size used being slightly larger than the last fine sand, while the last emery grain size used is *very* much smaller. Emery as obtained from the suppliers, contains many particles which are too coarse for use as received. Accordingly, it is fed first into a ball mill, to which the recovered emery also is fed, and thoroughly ground. Emery is graded, using the same flotation principle as that used in grading sand. However, the quantities involved are tremendously smaller, and the methods used are modified accordingly.

The grinder runners are faced with heavy cast-iron blocks. These blocks are cast in more or less

pie-shaped segments. There is a very thin backing plate with blocks which vary from 4 inch cubes to small triangular segments protruding from it. The heavy cast-iron grinder heads are faced with 2 inch thick oak planking and the grinder blocks are in turn screwed to this oak deck, each segment in proper relation to its neighbors, so that there are both radial and circumferential passageways for the sand slurry to pass from the center of the runner to the outside edges. There has been little, if any, change in the structure of the actual working face of a grinder runner through the years. After the grinder heads have been plated they are put on a round deck similar to the old grinding table and ground in with sand against the iron-plated face of the table, so that there are no protruding high spots on the working face. Then the grinder runner is ready to go into service in grinding glass, usually starting in rough sand.

Grinding is accomplished by crushing sand between the glass surface and the cast-iron blocks of the grinder head. As the sand disrupts in crushing, it spalls out tiny chips from the glass surface

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By comparison of earlier days, this laying yard is scrupulously clean. The laying yard, where the glass is bedded in plaster of Paris, is spotted on the flow chart below.

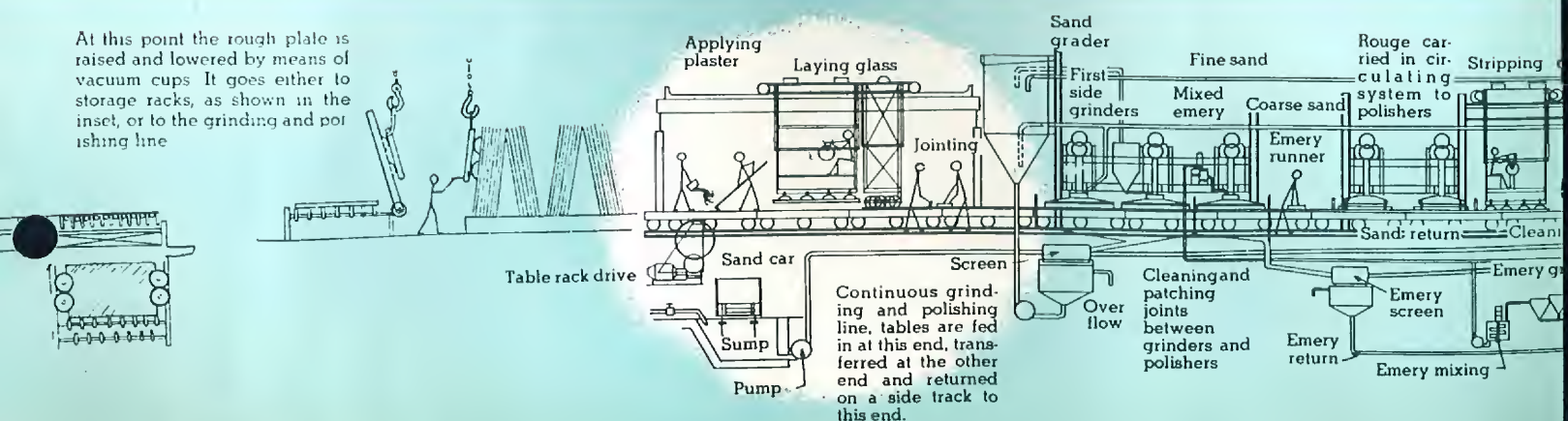
until it has been made perfectly level and relatively very, very smooth. As the blocks wear away, the grinders are moved progressively to finer and finer sand, and finally, on the emery runners, there is almost no protruding block beyond the back plate of the cast-iron. Both the grinder and polisher runners are electrically driven, individually, through vertical shafts in the trunks and horizontal constant speed motors overhead. They are aligned over the center line of the ribbon and the runners overhang the decks on either side by a considerable amount. The grinder runners at Works Nos. 1 and 6 are 9 feet in diameter, while at Works Nos. 4 and 9 they are 13 feet in diameter. The 9 foot runners operate at 56 RPM, while the 13 foot ones operate at 46.47 RPM. The position of the runners relative to the glass, and the consequent pressure against the glass, is manually controlled. The load on the motor is indicated by a wattmeter at each control wheel and the pressure adjusted to maintain the desired load on the motor. The glass blanks cannot initially be set on the decks in a uniform plane, while the runners at any given moment are in

a fixed position at a fixed distance above the decks. The result in the grinders is a wide variation in the load on the rough sand runners which are essentially leveling the glass at the same time that they are themselves being ground away. The load on successive runners, as the sands fed become finer, becomes more and more stable as the glass becomes flatter and change of load results only from the slow erosion of the block faces. The decks move through the grinders and polishers at a uniform speed, driven by a variable speed motor through a pinion connected to the motor and driving a rack gear attached to the under sides of the tables. The speed may be as low as 60 inches per minute and is varied only as required to suit the type of glass being produced.

As the glass leaves the grinders, it enters what is known as the middle yard. Here a gang of men scrape out the plaster between adjacent pieces of glass and along the edges of the table to remove any accumulated sand or emery. Where the glass has been chipped or cracked in the grinding process, the chipped or cracked glass is removed and small gaps cut around the chipped places. It is

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At this point the rough plate is raised and lowered by means of vacuum cups. It goes either to storage racks, as shown in the inset, or to the grinding and polishing line.





From the grinders, the glass progresses through the middle yard where plaster of Paris is used to fill joints, borders, and gaps preparatory to polishing.

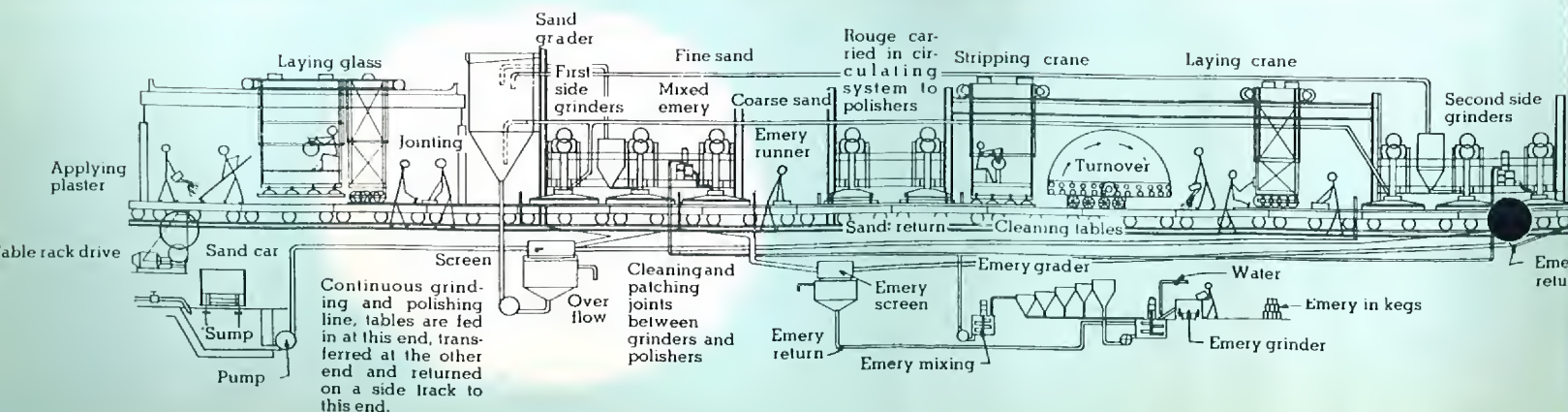
highly important that all gaps in the line shall be full and all joints free of sand or emery when the glass goes under the polishers, in order that a proper finish may be secured on the remaining glass. When the repairs in the glass set have been completed, a very stiff plaster mixture is poured onto the deck, and the men rebuild the border and the joints by troweling the plaster into place with long wooden paddles. All of this work is accomplished with sufficient rapidity that the border and joint plaster has again set up before the glass passes under the first polisher runner.

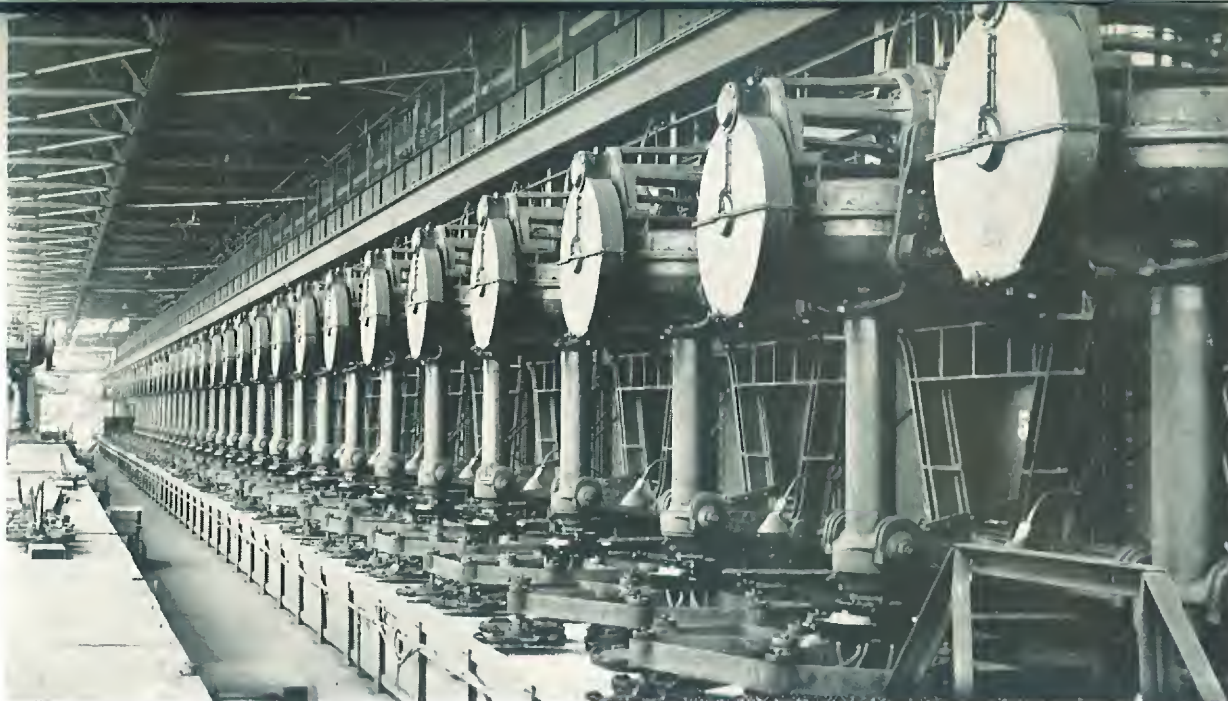
The polisher runners are usually called spiders, since they are cast-iron wheels with radial spokes and two circular sets of dead-eye bearings. The polisher blocks are heavy cast-iron discs, faced with polisher felts which, when new, are about 1 inch thick. The polisher felts are squares of the proper dimension so that the diagonals are considerably greater than the diameter of the cast-iron blocks. The felts are clamped to the cast-iron blocks by the corners only and are held by a steel hoop, which is forced into place by hydraulic pres-

sure. The felts are used until they wear down sufficiently to break through. Once affixed to a block, they are never removed until it is necessary to replace them with a new felt. In the center of the cast-iron block there is provided a universal joint bearing into which fits a ball-ended spindle. This spindle in turn fits into the dead-eye bearing in the polisher spider quite loosely, so that it is free to move up and down. It is prevented from dropping out of place when the spider is lifted by a cotter pin through the spindle. In the polishing process the entire weight of the felts, block and spindle acts against the glass, and since the spindle rides freely in the dead-eyes of the spider, no additional pressure can be applied. Clear water is fed to the first two or three polisher runners in order that the glass may be washed free from plaster from the middle yard, and then to obtain a polish, rouge is fed to the runners on down the line.

Rouge as used in the polishing shop is actually a suspension of ferric oxide (Fe_2O_3) in a solution of ferrous sulphate, derived from the pickling liquor used in steel mills for cleaning sheet and

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An idea of the dimensions of the grinders and polishers may be gained from these pictures rather than the chart below. The polishing room has a red decor—from the rouge used.

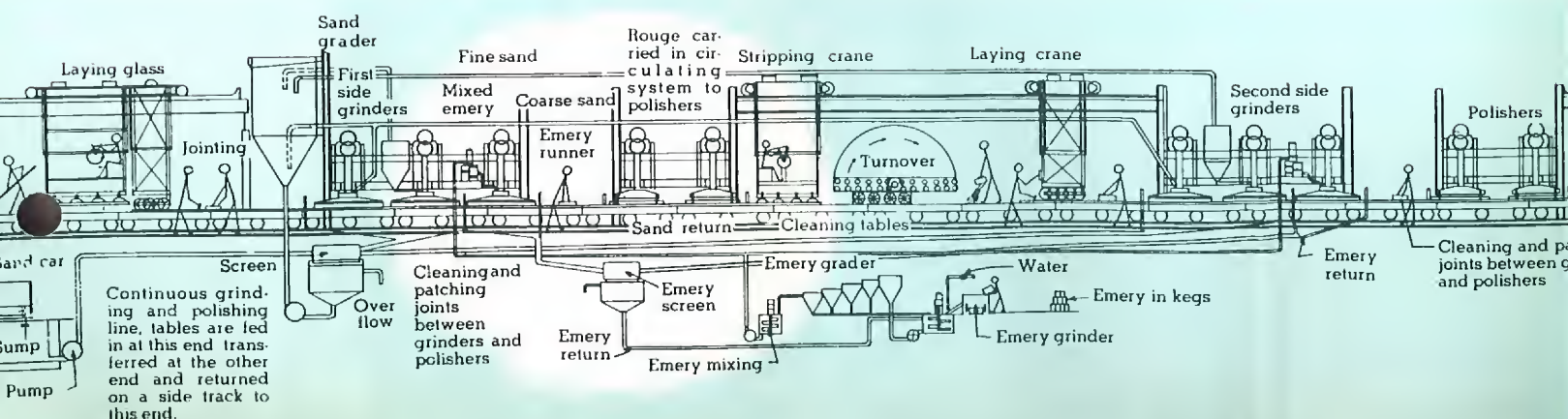
other products. This pickling liquor is essentially sulphuric acid to begin with, but in the process of pickling, becomes a concentrated solution of ferrous sulphate, which crystallizes and is then known as copperas. The rouge used is very nearly all chemically prepared ferric oxide, sold by several chemical companies directly to the glass industry. The strength of the copperas solution and concentration of the rouge suspended in it, are both most carefully controlled so that exactly the right proportions are present to face the polisher blocks with a coating of soft rouge. If the rouge is allowed to get too hard, polishing cannot be accomplished, and conversely, if the rouge is too soft, or too much copperas liquor is present, the polish will be very incomplete.

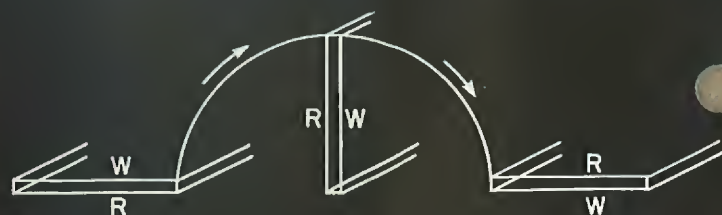
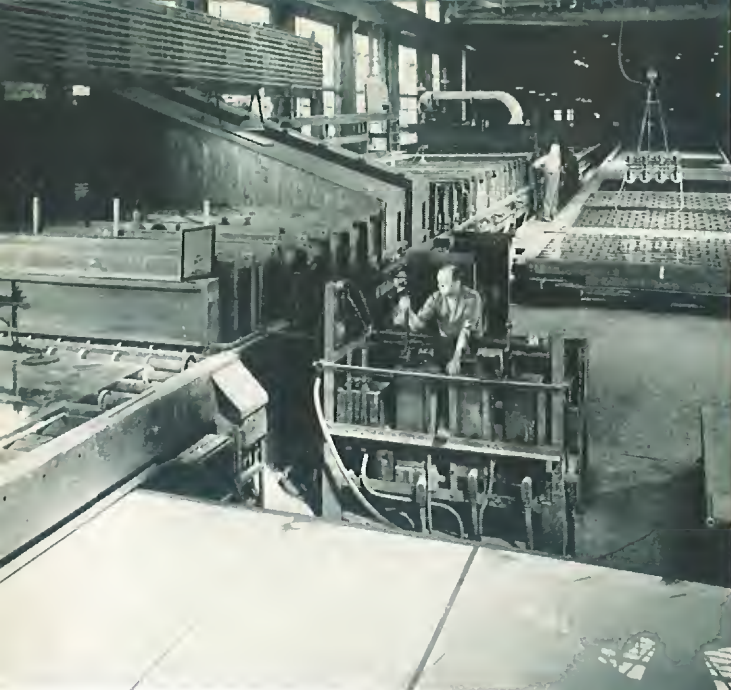
Rouge is fed quite freely to the first 4 polishers so that those runners never build up a very heavy face of rouge. As the glass progresses down the polisher line, however, the amount of rouge fed is gradually reduced so that more and more of the moisture is evaporated, and more and more of the rouge adheres to the felt faces of the blocks.

The faces of the blocks are examined from time to time to see that they remain soft and moist, and when signs of hardening appear, the faces are scraped free of rouge and the process started over again. In the polishing process, very considerable heat is generated in the surface of the glass, and it is thought that the polishing of glass is a result at once of abrasion and of actual flowing of the tiny points on the surface of the glass resulting from the grinding process.

As the decks leave the end of the line, the first-side grinding and polishing has been completed. The ears are then picked up by a so-called transfer car and moved to the other side of the building where they are returned to the laying yard on a separate track. At the laying yard, the glass is stripped from the deck, turned over, and relaid on a line of tables paralleling the first side line. Second side grinding and polishing is accomplished just as in the case of first side. The tables used for first side grinding and polishing are seldom interchanged with those used for the second side. In other words, the same tables are

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W, first side to be ground and polished

Sides are reversed in turnover and laying yard preparatory to second side grinding and polishing.

R, becomes last surface to be ground and polished. Subsequent cutting is done on this surface.

The glass is stripped from the decks and goes into a washing machine and then to the wareroom. Plate glass has a right and wrong side to the glass men.

always used to grind the first side of the glass and those tables are never used on the second side ribbon, and conversely. The continuous grinding and polishing equipment at Works Nos. 4 and 9 will handle glass 124 inches wide by 220 inches long. Standard production is 124 inches wide by 143½ inches long. At Works Nos. 1 and 6 the grinding and polishing decks will carry glass 72 inches by 130 inches.

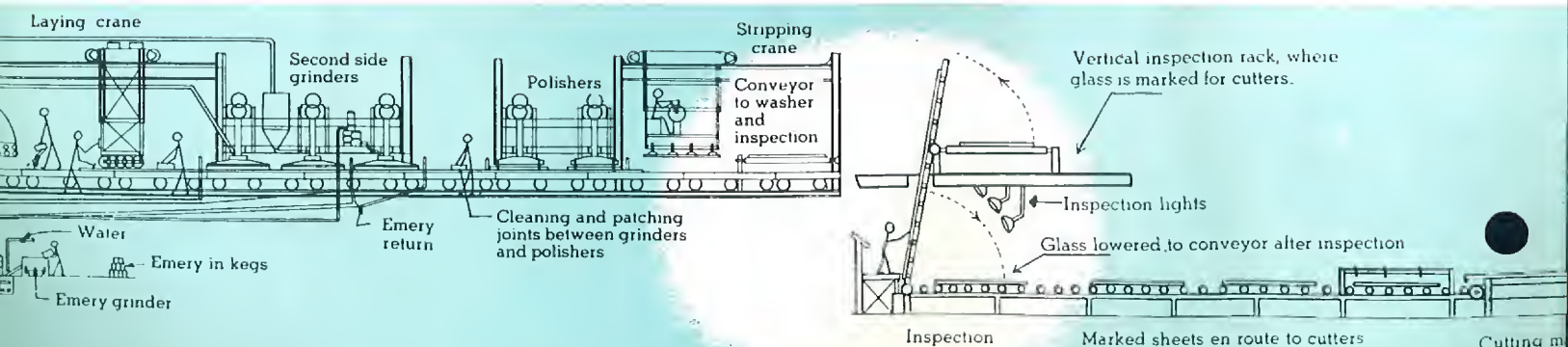
As the glass reaches the end of the second side polishing line, it is stripped from the deck by blowing compressed air between the glass and the deck. It is then picked up and placed on a conveyor, which carries it through the washing machine where it is strongly sprayed with a solution of muriatic (hydrochloric) acid and clear water, scrubbed with brushes, and finally wiped off between rubber squeegees. At the end of the washer, it is set on wareroom buggies, to be taken to the wareroom for examination and cutting to size. In general, the finish of the second side is somewhat better than that on the first side, for a number of reasons. The second side is the right side

of the glass and should remain the upper or cutting surface in subsequent fabrication. It may be identified by the score marks of the original cuts in the factory wareroom. This is the surface best suited for the application of silver in mirror making and in certain specialized uses the proper surface for contact with other materials. Except for the identifying score marks, it is not possible by visual inspection to differentiate between the two surfaces.

In the grinding and polishing shops an assistant superintendent and his assistants are responsible for all phases of the process which, to sum up, include the laying of the glass, the grading of the sand, the grinding of the glass, the readjustments handled in the middle yard between the grinders and polishers, the proper mixing of the rouge, and the control of the quantities supplied to each runner, supervision of the stripping yard, and the wash house.

Despite the exacting care with which all plate glass is made it never has been possible to produce a light of appreciable size entirely free of in-

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The wareroom examining stand for final inspection is spotlighted in the flow chart below. An example of precision handling equipment.

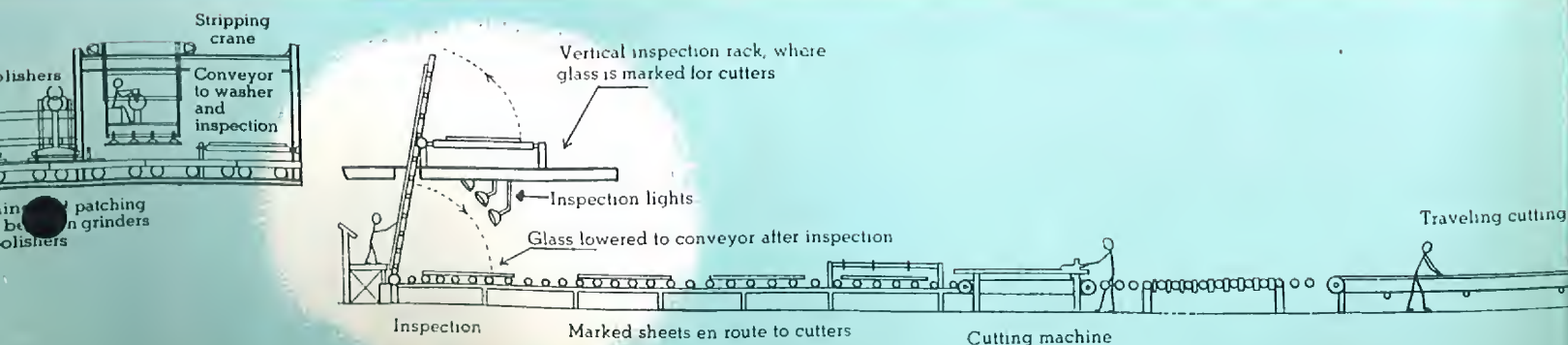
herent flaws. Quality gradations are therefore a matter of extremely careful selection to determine standards of suitability for specific purposes. Such suitable areas may occur at random throughout the continuous sheet and must be cut from the larger plates within boundary lines established by the examiner who has carefully observed every square inch of the finished ground and polished glass under intense revealing illumination directed through both the edges and the surface of the glass.

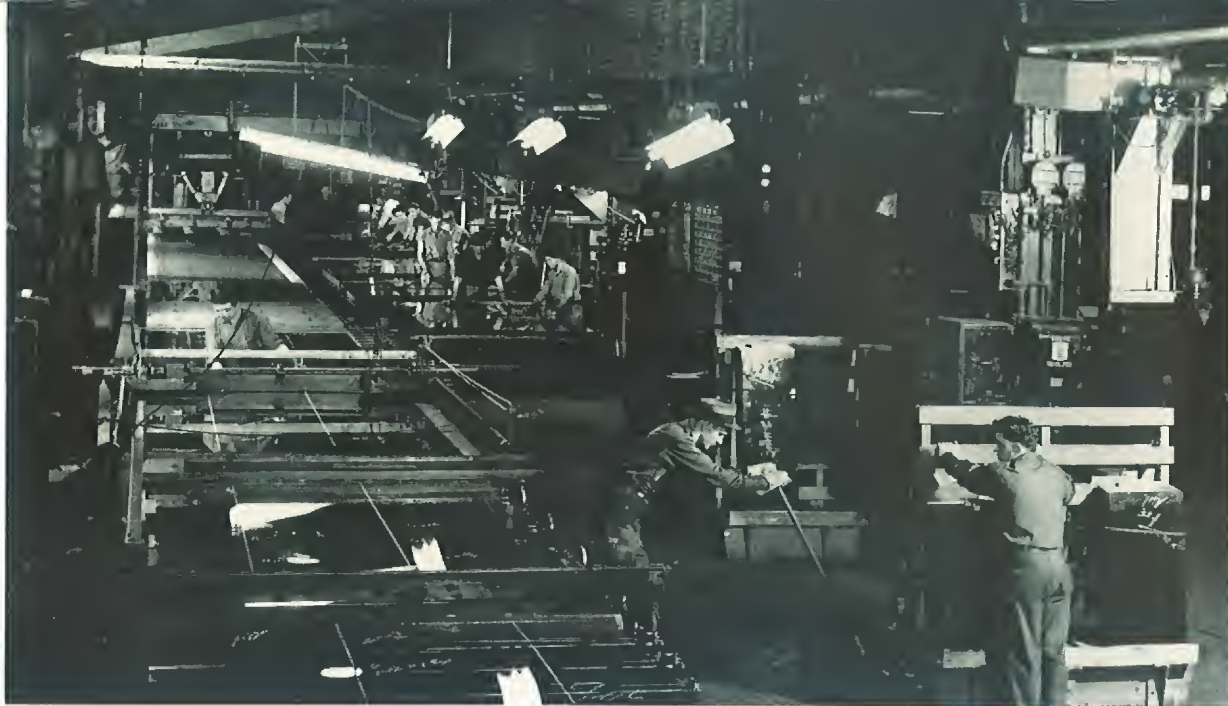
In the wareroom, the glass is removed from the wareroom buggies and placed upon vertically movable racks, one plate at a time. The motion of these racks is controlled by the examiner. The examiners inspect the glass for perfection of finish and, with common chalk, mark on the plate any internal or surface defects noted in the glass. The plate is divided up by chalk marks into sections which will permit the cutting of required sizes and qualities. The glass is then moved to a conveyor which carries it to the cutting tables where cutters, following the instructions chalked

on the plate by the examiner, cut it up into the required dimensions. Frequently, guide sticks, notched off to the required dimensions, are used as a time-saving means for getting accurate cutting. At this stage the glasses are cut accurately into rectangles. The glass is squared up by the use of a glass cutter's square, to very good accuracy. Quite often, particularly in the case of very large plates, the glass is moved directly from the examining booth to the finished glass storage rack, to be held until needed for filling orders of unusual dimensions.

A very considerable quantity of large size glass is held available for store window replacement and similar use, at all times. Often, the orders on hand cannot be cut economically from a given plate of glass, and that glass also goes into the wareroom storage racks for later use. The objective of cutting the largest possible amount of the highest quality of glass from any plate is kept constantly in mind and every effort exerted to that end. Although there are several qualities which are thoroughly defined by Federal Speci-

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The lengthwise cuts as indicated by the examiner with chalk lines are made in the cutting room. From the cutting room the finished polished plate glass goes by trucks to the packing room.

fications (See Section I), approximately 95 per cent of the total production and sales volume is included among the quality known as glazing quality. From the cutting table, the glass is piled on edge on small buggies, to be moved to the shipping room.

The wareroom and shipping departments are usually under the supervision of the wareroom superintendent, who is responsible for the glass from the moment it leaves the washing machine at the grinders and polishers to the time when it is placed on cars in the shipping room. In the shipping room, the wareroom superintendent has supervision over the box shop, straw storage, paper supply, and the packing and loading of the glass. Since there are no general standard sizes, boxes are fabricated to meet the requirements of each individual order as needed, and every effort is made to avoid packing different sized glasses in the same box.

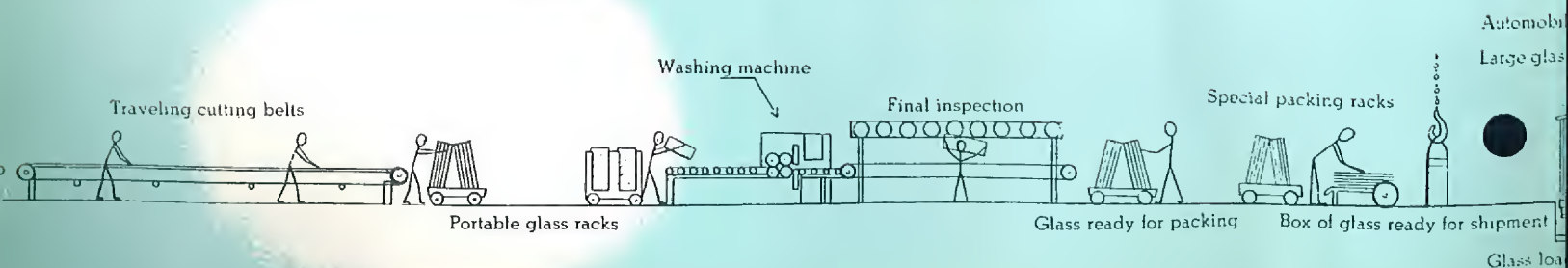
The glass is moved into the Shipping Department on the small wareroom buggies used to assemble orders, as indicated previously. Each

order is assembled separately from any other order, although one buggy may contain several orders, or several buggies may be required for a single order. The Packing Department foreman orders from the box shop the boxes needed for each day's shipment, and these are moved into the Shipping Department as completed.

Newsprint paper is purchased in the same size rolls as supplied to the printing industry, and is cut to size as required for interleaving between the glass on each order. This paper has an acid-alkali pH value of 5 to 5.5 which is exactly right for packaging glass.

The box is laid on its largest face on special skids so constructed that when packed, the box may easily be tilted into position so that the glasses are on edge. A bed layer of straw is placed in the bottom of the box, then one or two sheets of newsprint, and then the glass laid in, flat, alternately with sheets of newsprint. Frequently, when packing glass under 120 united inches, several piles are packed into the same case, and wood separators, protected by corrugated paper,

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Straw, paper and stout wooden boxes protect the glass for shipping to the numerous warehouses throughout the country and abroad.

are set on edge between the piles. Every effort is made to see that only well-seasoned dry wood is used for glass packing cases. The boxes are built about 4 inches larger on each dimension than the glass to be packed, and due allowance is made for the spacers.

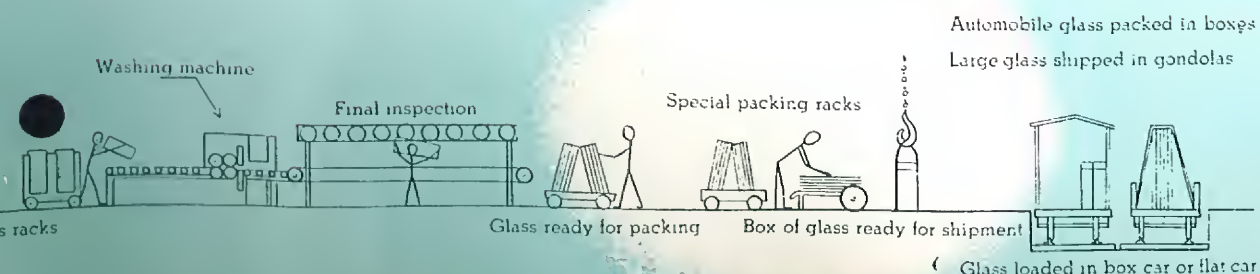
When all the glass has been packed into the box, straw is rammed into the spaces between the glass and the box walls, using wooden wedges similar to caulking tools, until the glass is thoroughly elamped in place. Then a sheet of newsprint paper is placed over the glass, a heavy layer of straw and then the box cover is nailed in place. The box is stenciled with the order number and shipping instructions and loaded either by overhead crane or by hand into railroad ears or motor truck. Special railroad ears, with dropped wells, are available for the shipment of large sizes.

The foregoing packaging practice is standard for glass, over 120 united inches (length and width), for ordinary domestic shipment by rail in boxcars, or by motor truck. Corrugated paper board is usually employed instead of straw in the

packing of glass under 120 united inches. When the glass is to be shipped in open railroad ears, for export or on specific instruction of the purchaser, a type of moisture-resistant paper is also used. In the packing of undersized glass, the box is lined with the moisture-resistant paper, packed, and the paper folded over to envelop the whole content and the cover nailed in place. For oversized glass, the moisture-resistant paper is placed upon the bed layer of straw, the glass piled into the box as before, the moisture-resistant paper folded over to envelop the glass, and the box then rammed tight with straw and closed. In open railroad cars, the cases of glass are further protected with watersheds of wood and moisture-resistant paper.

Usually plate glass cases are packed to have a maximum shipping weight of 3,000 pounds and to contain approximately 800 square feet of $\frac{1}{4}$ inch equivalent thickness.

Before discussing polished plate glass products, we will turn aside to describe the pot method of manufacture, as it differs from the tank method.





Here we reverse our field and go back to the manufacture of plate glass by the pot method. The charge is placed in the pot by the expertly manipulated shovel.

Where the glass is being melted in pots, the mixed batch is placed in hoppers which are carried bodily to the front of the furnace, and the batch transferred into the pot by means of large shovels or ladles.

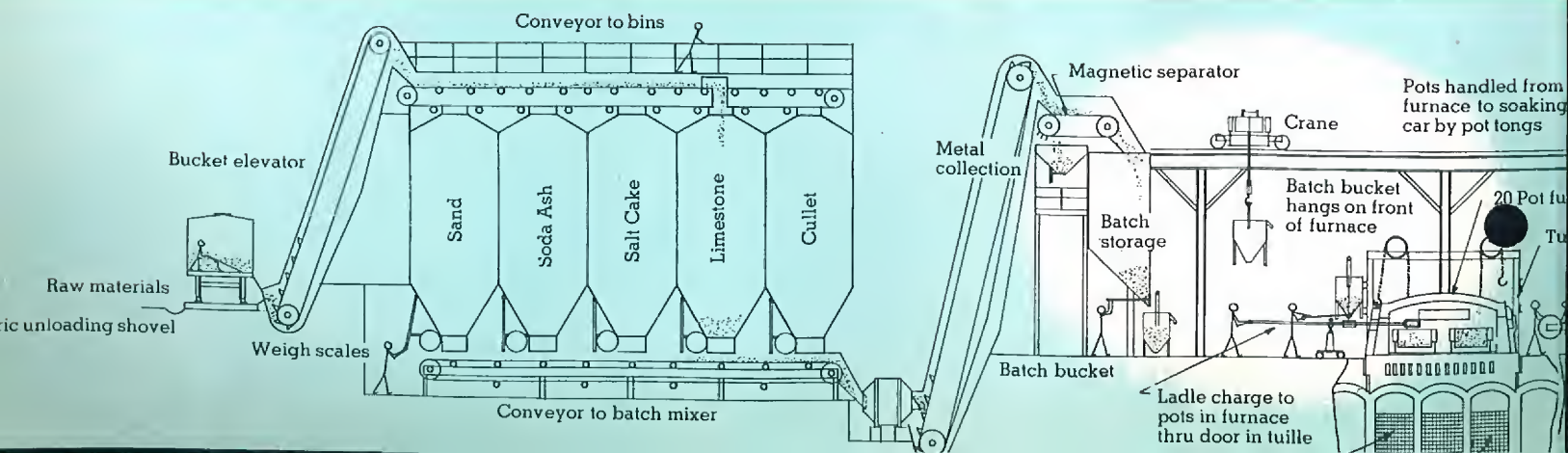
Obviously, the prime prerequisite of the successful making of glass in pots is the availability of suitable and satisfactory containers or crucibles. Throughout the glass industry, these crucibles are known as pots—covered pots for certain special types of glass, open pots for plate glass and most optical glass and other special flat glass products. The pot must be of good refractory characteristics to ensure its remaining rigid at the glass-founding temperatures; it must withstand the solvent action of the finished molten glass as well as of the fluxes in the glass batch; and any corrosion of the pot which may occur must not introduce defects such as cord, ream or stones into the finished product.

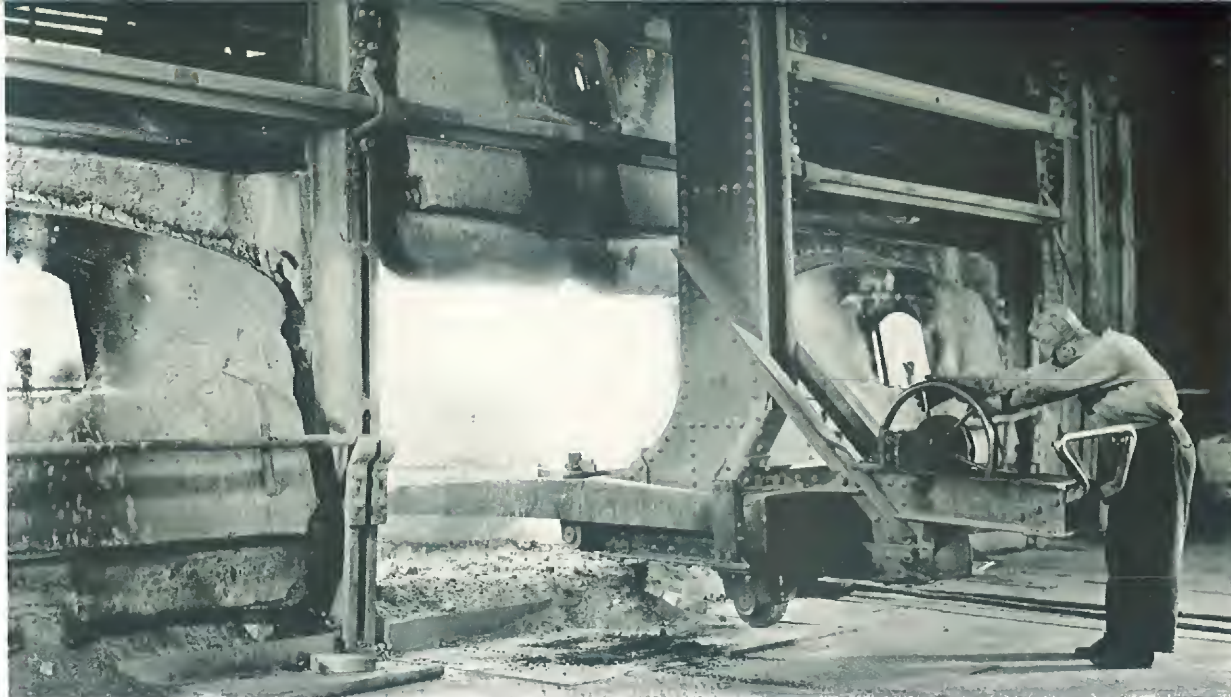
One of the larger size plate glass pots now in use is oval shaped, being approximately 72 inches long, 54 inches wide and 36 inches deep. The side

walls are approximately 6½ inches thick, the bottom approximately 7½ inches thick. The finished pot weighs approximately 2 tons and will hold over 2½ tons of glass.

The Pittsburgh Plate Glass Company has pioneered in the manufacture of better glass melting pots. Through the technical development work of the research laboratory, with the co-operation and assistance of the personnel of the various factories, the Pouring Process of making pots has been developed and has superseded the former method of building pots by hand from plastic batch. It was found that certain types and mixtures of clay treated with very small quantities of chemicals (electrolytes) can be mixed with water to form a thick creamy pot batch mixture or "slip." This slip may be poured into plaster molds to form a pot. Due to the action of the electrolytes the slip is produced with the addition of the same or less water than would ordinarily be needed to make a plastic mass.

A pot is cast in two stages or layers—an outside layer and an inside lining. The batch is iden-





Removing the finished pot by giant tongs of an electric crane preparatory to transfer to the soaking pit. This action is spotted on the flow chart below.

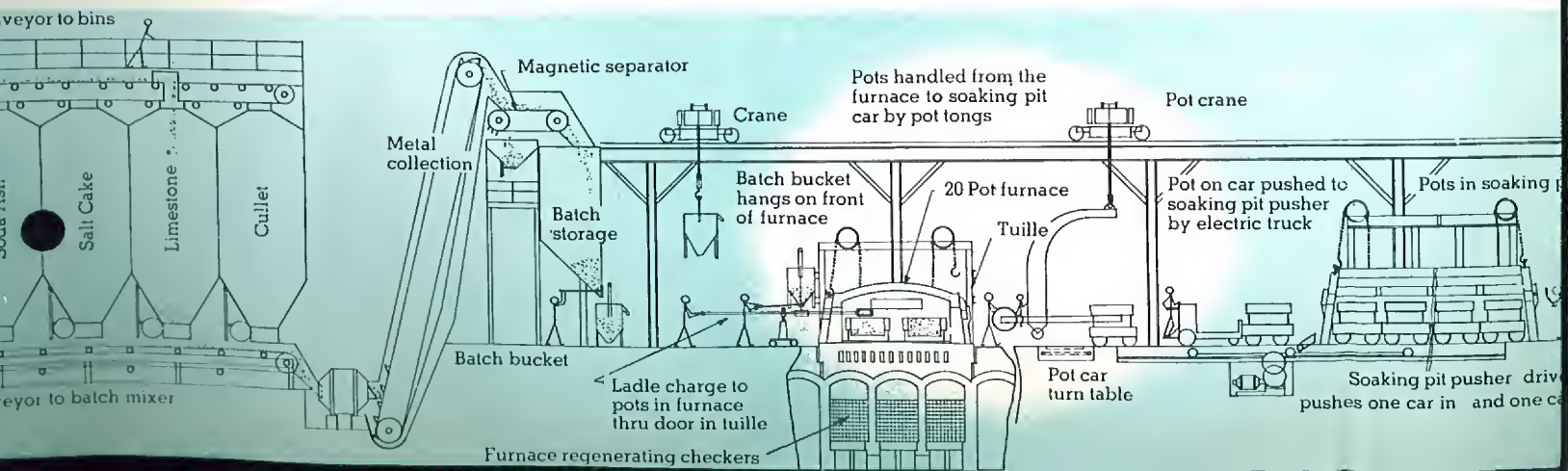
tical except that one is more coarse in texture than the other. The coarser texture is used in the outside batch to better withstand the temperature changes to which the pot is subjected in casting. A fine dense texture better resists the corroding action of the molten glass, so the fine-grained batch is used for the pot lining.

The straight-line production system designed by Pittsburgh Plate Glass Company Engineering Department is capable of producing 17 large sized pots per day, although the actual time elapsed from empty mold to rigid formed pot is approximately 3 days. Preliminary drying requires from 4 to 6 days, and then the pot must spend 10 days in the humidity dryer before going to storage, or if immediately needed, before going to the furnace hall. Thus 19 days are required to produce a stock pot. When the pot is taken to the furnace hall, it is put into a hot room at 140°F. to 180°F. and is held there about 10 days to drive off the last traces of free moisture, before entering the pot arch. In this straight-line production, the pot arch is actually a car tunnel kiln in which the tem-

perature gradually increases from 150°F. at the cold or entering end to 2000°F. at the delivery end. Each pot rests on an individual car and is moved progressively through the kiln, which will hold 36 pots. On the 4-hour schedule of normal operation, 6 days are required to bring the pot up to temperature. In emergencies, several steps may be speeded up, which will reduce the time required to convert raw clay to finished melting pot from the 35 days enumerated to 30 days. The old handmade pot requirement of 8 to 10 months, with a storage capacity of 5,000 pots, compares with 30 days and a storage capacity of 500 finished pots.

Pot furnaces are built to accommodate from 1 to 20 pots at a melt and any given furnace is always filled to approximate capacity and with glasses requiring the same melting cycle. The bottom of a pot furnace is built of heavy masonry. Over this bottom is a layer of open masonry construction with small flues running from the center to the four corners, there connecting with small vent stacks, which permits air circulation and

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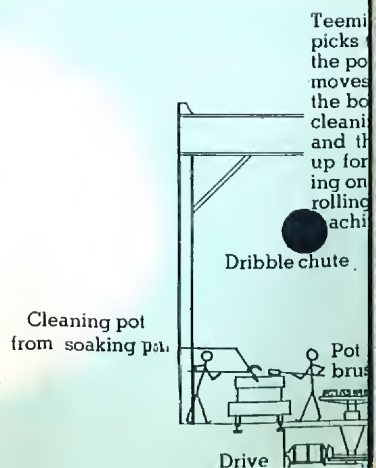
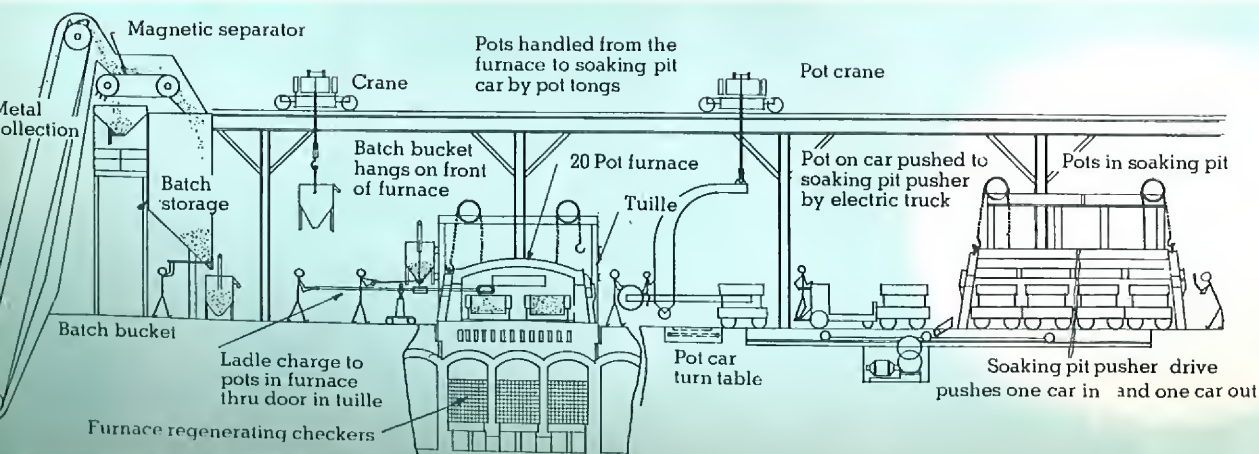
The finished pot is moved from the soaking pit and locked securely into the teeming crane—preparatory to casting.

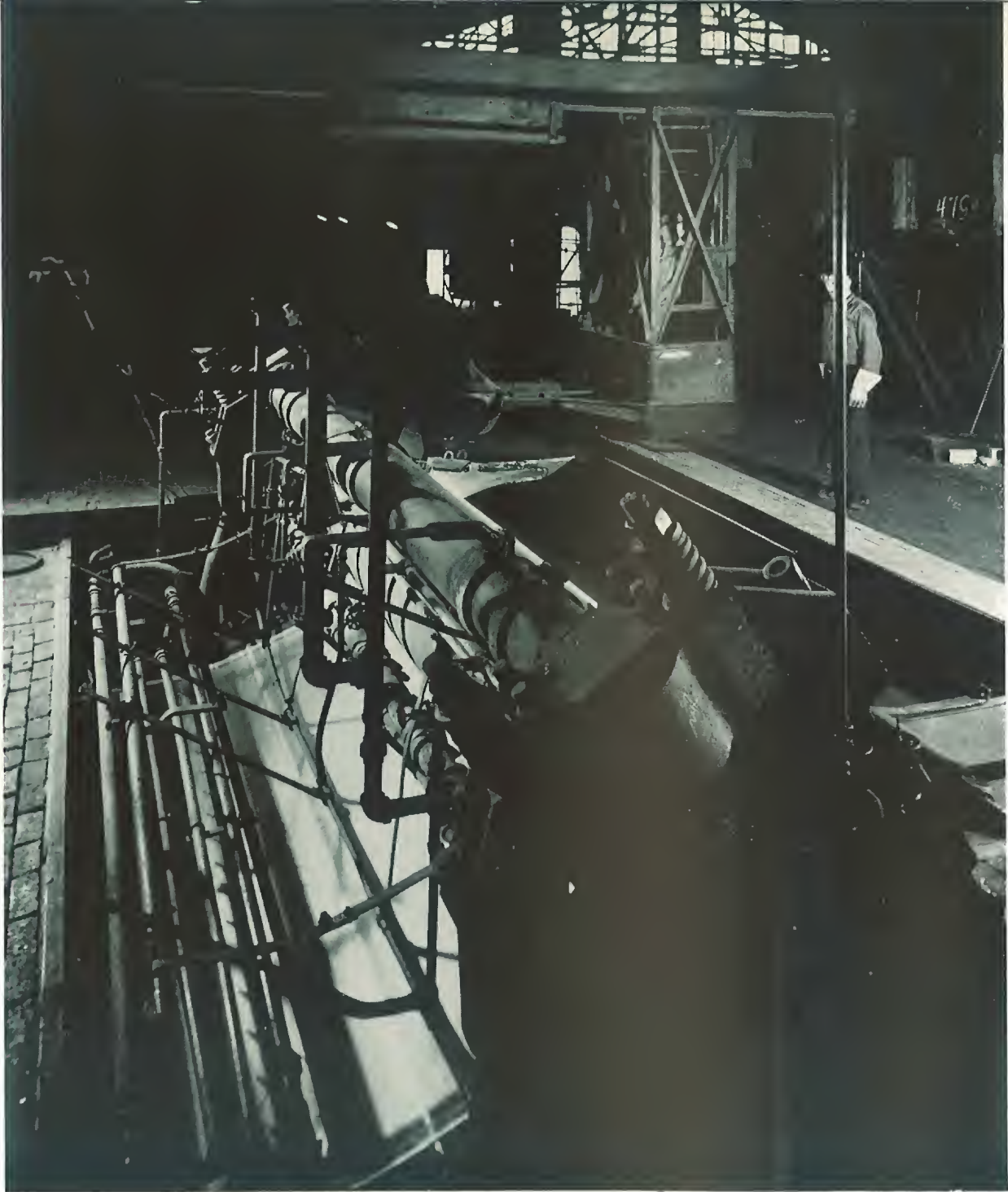
helps cool the furnace floor. Over this are laid several courses of refractory brick to form a level surface and on top, moist chunks of fire clay are spread and tamped down forming a bed 6 or 8 inches deep, which gives a thoroughly smooth, flat "siege" upon which the pots rest.

The crown of the furnace is built of silica brick, just as in the tank furnace. Actually, there are no walls, but rather the crown is supported on corner columns and cross arches and is domed. A multiple-pot furnace is made up of a succession of 4-pot units, separated only by refractory pillars or piers which support the roof and refractory arches over the tuille openings. The sides are actually huge clay doors called tuilles which may be moved vertically up and down against these same columns. Similar doors are set directly in line on opposite sides of the furnace, and each gives access to an area large enough to accommodate 4 pots in a cluster, although only the 2 pots immediately adjacent to a given door are handled through that opening. The ends of the furnace are simple silica brick walls which close in the arch of the crown.

Baffle walls within the enclosed space a short distance from the end walls, effectively form ports through which the mixture of air and gas is admitted to the furnace. The fires are alternated from one end to the other at regular set intervals. The flame sweeps against the crown and swirls around the pots, and the whole interior of the furnace reaches a white heat. Melting of the batch in the pots is caused chiefly by radiation from the crown. The life of a pot furnace depends principally upon the life of the cross-arches. These arches and piers or pillars are constructed of refractory clay shapes, exposed directly to the slagging action of the flames and alkaline vapors from the melting glass batch. The arches are especially subject to slagging, since they are exposed to the flames on two sides, while one side is insulated against heat loss by the silica brick of the crown and the other is partially insulated by the tuille. After about 18 to 24 months, the arches become too weak to safely sustain the load of the crown, and the furnaces are shut down and rebuilt. Refractories are used for these arches because of their less liability to damage by alter-

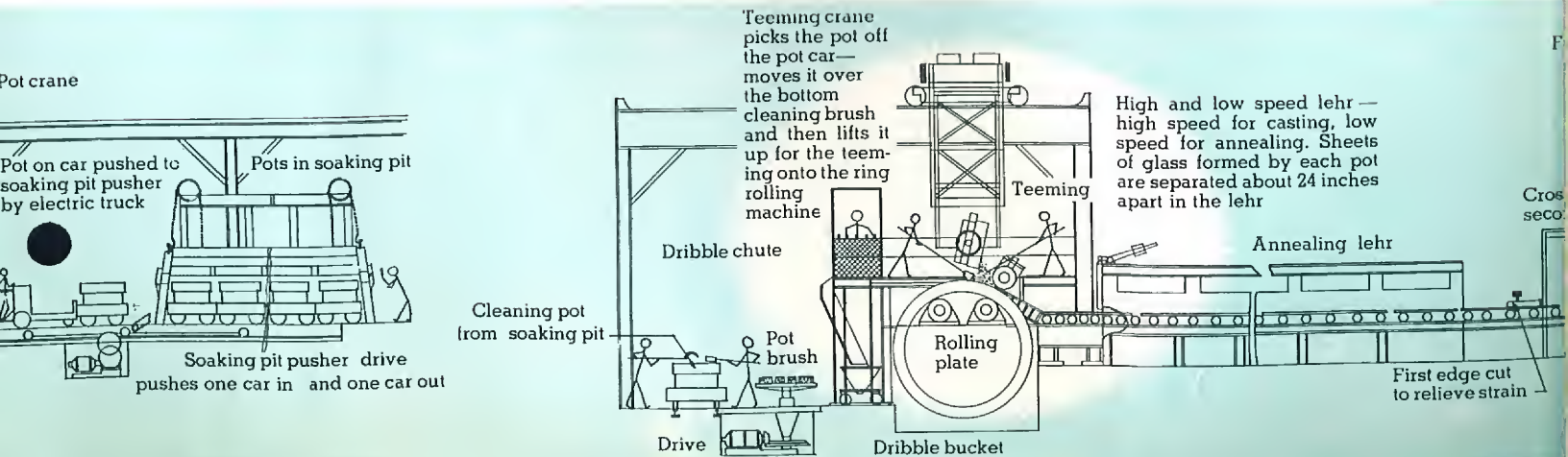
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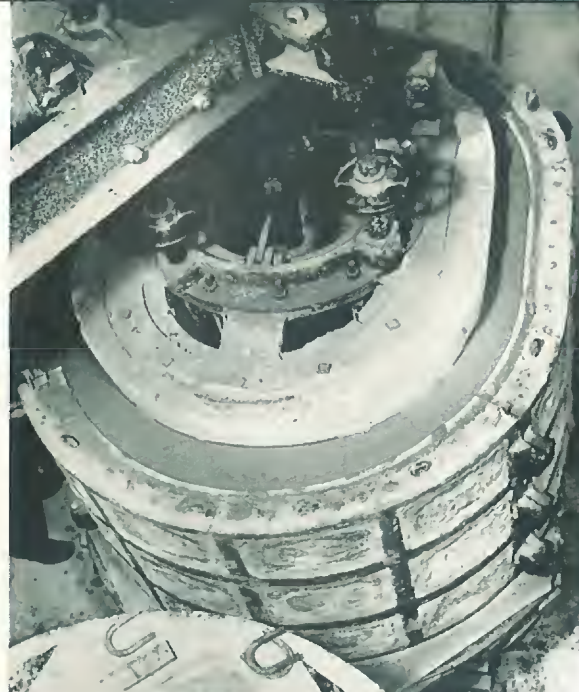




Almost all of the glass from the pot has been formed into a sheet as spotlighted on the flow diagram.

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Ponderous machines force softened clay into the stoutly reinforced form of a glass-melting pot. The clay is made to meticulous specifications.

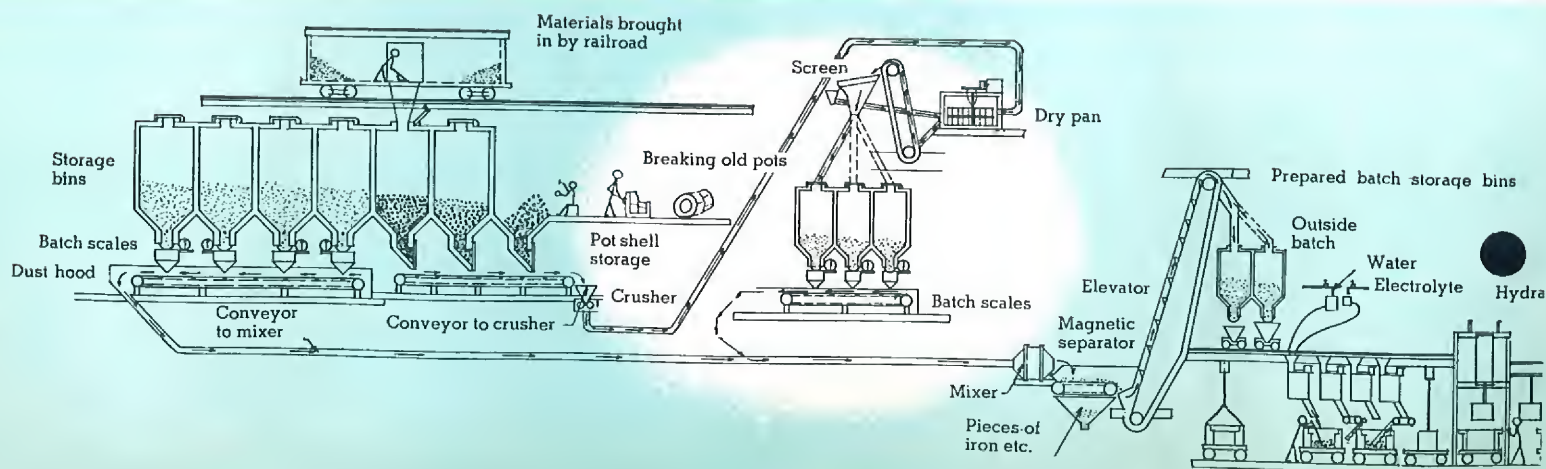
nate expansion and contraction, under load, when the heat is increased or reduced at the start or finish of a melt.

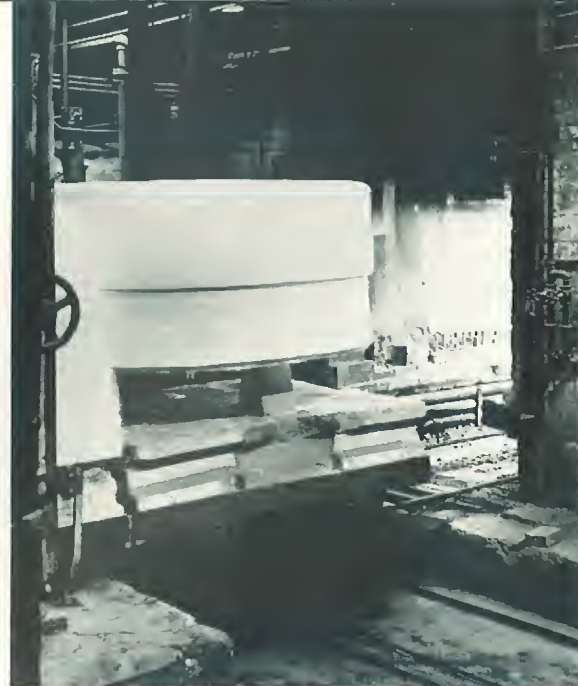
New pots are kept constantly at hand ready for immediate use in the event that any pots in service should fail. These new pots, to be immediately available, must be hot enough to be set directly into the furnace. Preheating requires very careful supervision and exacting control of temperatures in special furnaces called pot arches, to avoid breaking of the pot in the process. Every effort is made to keep as short as possible the time during which the pots are out of the furnace for casting, so that they may not cool appreciably below 2000°F. before again being placed in the furnace for another melt. The intense heat necessary to melt the glass, also causes some slagging of the pot. Some boiling over of the molten glass and some spillage of raw batch also may occur. The dross thus produced tends to make the pot stick to the siege, so anthracite breeze is scattered over the floor of the furnace just before a pot is set in, to reduce the tendency to stick.

Each tuille has a small square opening, the bottom of which is several inches over the top of the pots. The shovels full of batch are pushed into the furnace through this opening, moved into position above the pot to be filled, and dumped. This is entirely a hand operation in which little actual labor is required, since the ladle is carried on a movable pivot table and the pivot arm is very nearly counterbalanced. It is customary to fill a layer of cullet into a new pot in order to glaze the surfaces, and thereafter the pot is usually filled with twelve to fourteen ladles full of a mixture of raw batch and cullet until the metal very nearly fills the pot. Where more than one fill is necessary to have the pot full of molten glass, the previous fill is thoroughly melted before another is made. The melting cycle, from empty pot to finished metal varies according to the requirements of the case from 36 hours to 72 or more. The glass is said to be planc when all the foam has disappeared, and is fine when sample dips from the melt show no large seed in the ladle.

When the glass is finished, the pot is broken

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Plaster of Paris molds sculptured to exact dimensions yield the finished pot and contribute to improved glass production.

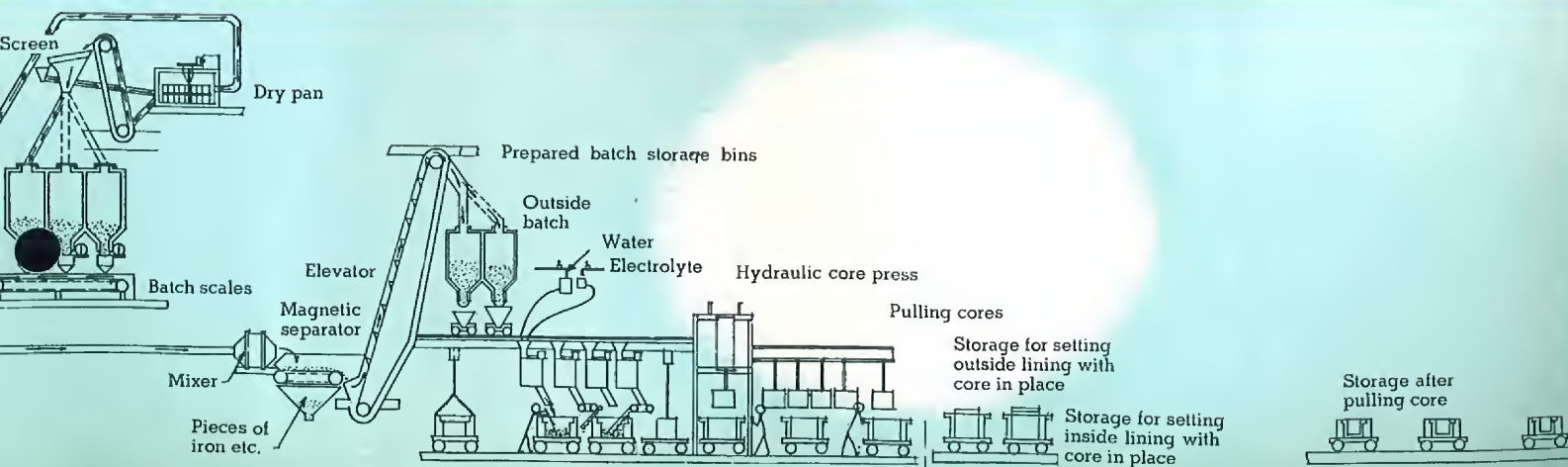
free from the sieve by huge tongs carried by an overhead electric crane and carried to the soaking pit or tunnel. The soaking pit is a tunnel kiln intended primarily to equalize the temperature of the molten metal in the pot and particularly to reduce the viscosity of the top layers of glass in the pot and bring it to casting temperature. Mechanical limitations permit the casting of only one pot every 7 minutes which is very much slower than the pots could be handled. The soaking pit also tends to enable prompt handling of all the pots from a furnace to the casting point with a minimum of delay.

In its proper turn the pot is moved out of the soaking pit, clamped in the jaws of the teeming crane, and on the way to the forming rolls, the bottom of the pot is thoroughly cleaned by revolving wire brushes, blown off with compressed air, or otherwise, and any possible floating particles on the surface of the glass are removed. Usually a cover is placed over the pot immediately upon its removal from the soaking pit to avoid having any foreign material fall into the glass.

The pot is then carried over the forming rolls and poured, all at once, while the crane moves back. This deposits a mass of glass more or less distributed evenly. The tailings from the pot fall into a skip at the end of the rolls and are returned to the pot for remelting. A mechanical hook is used to further distribute the mass of glass and to remove any extraneous material which may appear.

The casting or forming machine consists of two 124 inch long rolls set one above and considerably off center to the other. The top roll is 28 inches in diameter, water-cooled, while the lower or ring roll is about 12 feet in diameter. It is built up of heavy steel rings secured together edge to edge and carried on two 28 inch diameter rolls within the shell, so arranged that the top forming roll is in line with the forward supporting roll and the pressure developed in forming the sheet is taken up on the supporting roll. The ring roll is heated by gas flames to equalize and maintain the temperature so that the heat of the molten glass shall not unduly overheat and distort the roll. Casting

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Nearly perfect examples of the potmaker's skill emerge from the most modern type of humidity-controlled drying tunnel.

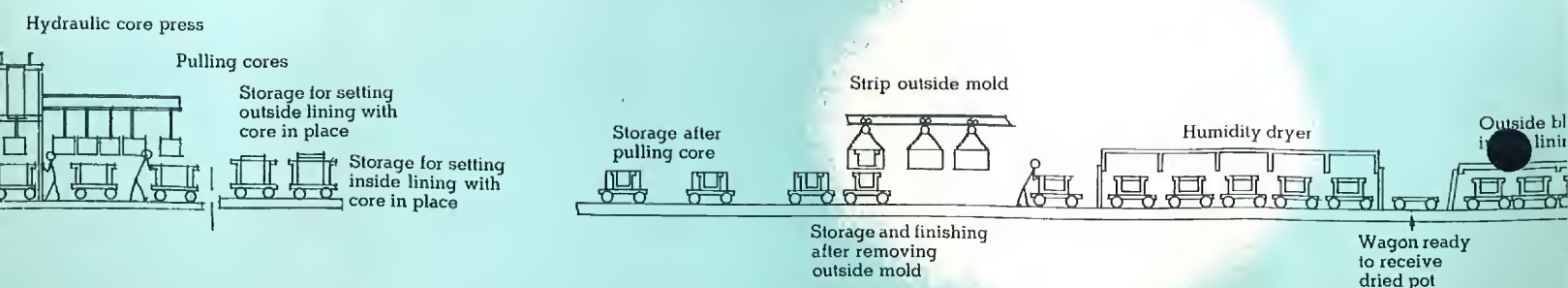
is performed at a speed of approximately 480 inches per minute, and each pot contains enough metal to make some 800 square feet of $\frac{3}{16}$ inch rough glass, or a plate about 123 inches wide and 65 feet long. As soon as the glass is all within the lehr, the speed is reduced automatically to 108 inches per minute to afford proper annealing, and 1 hour and 40 minutes after casting, the rough glass is examined, cut to size, and sent either to the grinders and polishers or to rough glass storage.

Polished plate glass derives its most distinguishing characteristic from the mechanical grinding and polishing of its surfaces, in parallel planes, which imparts an elegance and refinement that is evidenced by its lustrous sheen. It glorifies the quality of transparency by affording true vision without distortion. It may be used in innumerable ways for many different purposes and, constantly, new uses arise. As a result, many types or compositions of glass have been developed. Ofttimes, different types of glass are used for the same general application and frequently

several types of glass are combined in the same installation, to meet special requirements. Polished plate glass may be fabricated in various ways to meet specific or unusual needs. Many of these fabrication methods are widely used at glass distributing centers, warehouses, and jobbers as well as at the factories, and are described in detail under Section F. Other fabrications which are adequately handled only at the factories are discussed in Section C. The general physical and mechanical properties of the various glass products are shown under their proper headings in Section J.

REGULAR-NORMAL-POLISHED PLATE GLASS

The regular-normal-polished plate glass products, in all thicknesses, are typical soda-lime-silica glasses made up of approximately 71 per cent silica, 12 per cent lime, and 13 per cent soda. Another $2\frac{1}{2}$ per cent includes magnesia, alumina, arsenic pentoxide, and other ingredients which





These old pots are destined for rejuvenation in the form of grog for a new pot. This grog corresponds to cullet in glassmaking.

really are present as impurities. Magnesia is used to some extent deliberately, in quantities which may run as high as 2½ per cent.

The great volume of production is in the range of thickness from ¼ inch to ⅝ inch. Tanks are mass production units and consequently are used in founding glass for these thicknesses. Pots are used for some ¼ inch, nearly all ⅝ inch and all greater thicknesses.

In general, when people speak of plate glass, they have in mind, whether consciously or not, glass which is approximately ¼ inch thick. Frequently, thickness alone is the criterion by which many persons try to determine whether or not a given piece of glass is plate glass. Obviously, to the initiated, thickness is of relatively little importance, while surface flatness and parallelism of faces are paramount considerations. Internal or body perfection—metal—also should be taken into account, although this, like thickness, does not determine the issue. The metal, however, does have a distinct bearing on the quality of the product, both in polished plate glass and

window or sheet glass. While the beautiful highly polished surface of polished plate glass is substantially hard (approximately 6.5 referred to diamond 10 on the Moh scale of hardness) it is subject to abrasion. Scratches on the surface or surfaces also have an influence in evaluating the quality. Indifferent or careless handling can convert a plate of first silvering quality or even selected quality from a highly salable article to a reject. Warehousing of polished plate glass therefore requires most careful handling and strict supervision.

Warehouse stocks usually include an assortment of virtually all the polished plate glass products of the Company. Some products are stocked in large volume, while others (½ inch thick and heavier) may not be carried at all, as may be determined by the demand. Regular-normal-polished plate glass products may be obtained in almost any desired thickness from ¼ inch up to and including 1½ inch. In general, no special names are assigned to the various thicknesses, except for Vista plate glass.

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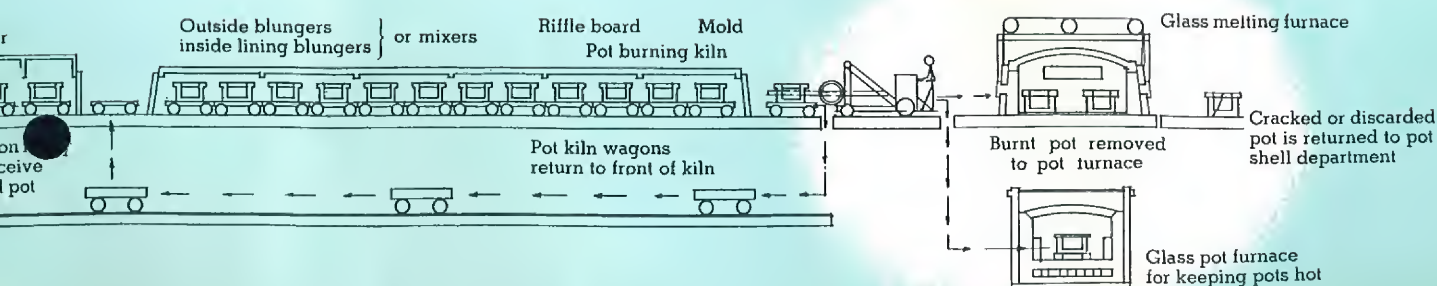




Plate glass enclosures around desks provide unobstructed illumination and complete privacy for discussion in a modern office.

VISTA PLATE GLASS

This product has been especially developed to enable the use of polished plate glass where ordinary window glass would otherwise have been used. It is designed in thickness ($\frac{1}{8}$ inch) and in weight, for use in the typical double-hung sash usually found in American homes. It has all the beauty of surface finish and metal quality obtainable in any other polished plate glass product, and affords that clarity of vision which can be secured only with polished plate glass. Vista plate glass has all the properties of regular-normal-polished plate glass products as listed in Section J. It is available in all sizes up to 72 inches wide by 123 inches long, although it is recommended that maximum window sizes be held under 12 square feet.

$\frac{3}{16}$ INCH THICK POLISHED PLATE GLASS

$\frac{3}{16}$ inch thick polished plate glass is produced principally at Works No. 1 at Creighton, Pennsylvania, and also at Works No. 9 at Crystal City, Missouri. It is especially intended for use in the manufacture of laminated safety plate glass—Duplate. However, it is available for other purposes, on special order. Upon occasion, it is possible to procure polished plate glass of even less thickness when the necessities of the case, and the volume involved, warrant special fabrication.

REGULAR

Although it is customary in the trade to indicate the thickness of polished plate glass desired, it is usually understood, when no other thickness is specified, that $\frac{1}{4}$ inch thickness is required. This is considered the standard base product, throughout the industry, and is the most widely used. There is a very considerable demand for $\frac{13}{64}$ inch thickness for the mirror industry, which uses a large portion of the total polished plate glass production. Accordingly, when thickness is not specified, it is necessary to exercise judgment in filling the order, and to take into account the source from which the order comes. Frequently, it becomes necessary to check with the customer, involving considerable delay in shipment. Thickness is a matter of real importance and should *always* be specified.

HEAVY POLISHED PLATE GLASS

This category includes all the polished plate glass products which are $\frac{3}{8}$ inch or more in thickness. The composition of the glass and the physical properties are the same as those of the lesser thicknesses. In standard products, the thicknesses are graduated in increments of $\frac{1}{8}$ inch up to and including $1\frac{1}{4}$ inch thickness. Thicknesses over $1\frac{1}{4}$ inch are not available in normal polished plate glass production. The physical beauty of heavy polished plate is at least equal to and in many

applications superior to the beauty of the more usual $\frac{1}{4}$ inch thickness. In many instances, the thickness of the glass is the factor which determines the maximum size of polished plate glass to be used. From an engineering standpoint, the heavy polished plate glass products are oftentimes considered as structural materials and the sizes and thicknesses to be used are determined by usual engineering methods. A factor of safety of 10 should be used in all such calculations except in the case of vertical windows subject only to wind load, when a factor of safety of 1 is used.

Heavy polished plate glass is produced at Works No. 6 at Ford City, Pennsylvania, by the pot melting process. A considerable quantity of all the several thicknesses is held in stock there and is readily available anywhere on short notice. The general physical and mechanical properties of the various glass products are shown under their proper headings in Section J.

OTHER POLISHED PLATE GLASS PRODUCTS

In addition to the regular polished plate glass line, the Pittsburgh Plate Glass Company produces a number of other standard polished plate glass items of more or less special or specific application. They differ from regular-normal-polished plate glass in composition and particularly in color. Each is identified as an individual product by a name indicative of some special property which it possesses and each will be described in the following paragraphs.

CRYSTALEX POLISHED PLATE GLASS

Crystalex was especially developed to afford the highest possible clarity of vision and to supply refrigerator showcase builders a more satisfactory glass for multiple glazing purposes. It is designed particularly to overcome the efflorescence which tends to appear on the faces of ordinary soda-lime glasses under rather special conditions. All silicates are hygroscopic to a greater or lesser degree and glasses, no exception to the rule, adsorb minute quantities of moisture in their surfaces. This moisture is rather loosely held and tends to evaporate and reabsorb with changing atmospheric conditions. Constant repetition of the cycle produces a crystalline deposit on the surfaces of the glass unless the crystals are themselves at least equally hygroscopic with the glass. Crystalex is designed to meet these conditions.



The Declaration of Independence permanently protected with bullet-resistant laminated X-ray Lead Glass.

Throughout the spectrum, Crystalex has the highest transmission values of any flat glass products available on the market. The extreme clarity of the glass is particularly notable where reds and blues are concerned. See Section J.

The very high transmission values in the ultra-violet region of the spectrum make Crystalex exceptionally useful for photographic and blueprint work, in which it tends to reduce printing time or electric power consumption. It is unusually suitable for edge-lighted signs where whiteness of the glass is important.

Crystalex is a soda-potash-lime-silica glass which also contains antimony. The lime content is about the same as in regular plate glass, the silica slightly less and the combined soda and potash slightly higher.

Crystalex is made in pots and ground and polished at Works No. 4 in Ford City, Pennsylvania. The various physical and mechanical



Distance and spacious reflections lend enchantment to the view. Plate glass mirrors and Carrara glass combine for a glamorous cocktail room.

properties are tabulated under Crystalex in Section J. It is available in $\frac{1}{8}$ inch and $\frac{1}{4}$ inch thickness only.

X-RAY LEAD POLISHED PLATE GLASS

X-ray lead glass is used in X-ray projection room windows, in industrial fluoroscopy for the study and inspection of metals or other opaque products and in other similar applications where protection of the observer or operator against X-ray emanation is important.

X-ray lead glass is a lead-barium-silica glass which contains approximately 61 per cent lead oxide, 8 per cent barium oxide, and 31 per cent silica. It is melted only in pots at Works No. 6 in Ford City, Pennsylvania, and is considerably more expensive and more difficult to produce than are most of the other polished plate glass products.

X-ray polished plate glass is a very technical, highly specialized product. It is marketed only as polished plate glass from 5.35 to 7.35 mm. thick (6.35 mm. is $\frac{1}{4}$ inch). The general physical and mechanical properties of this glass are shown in Section J. However, since some of the properties are unique, they are shown here.

Index of Refraction (Approximate) $N_d = 1.76$
Lead Equivalent (at 100 Kv.)

guaranteed minimum	0.30
Average Weight, approximately twice that of regular polished plate glass (6.35 mm. average thickness) lbs. per square foot	6.37
5.35 mm. thick X-ray lead polished plate glass under exposure (at 100 Kv.) X-ray, is equivalent to sheet lead	.0635 inch thick

At the present time, the Pittsburgh Plate Glass Company is the only domestic producer of X-ray lead polished plate glass. However, the quality of the product is exceptionally high in comparison with other similar products.

It is extremely soft and may be readily scratched with almost any metallic object. For this reason it is difficult to grind and polish and must at all times be handled with extreme care. The surfaces are subject to rapid deterioration under certain atmospheric conditions and by the attack of moisture from the hands, etc. It is usually packed between several layers of white blotting paper and should not be unwrapped until ready for use. It should be stored in a dry atmosphere away from the fumes of sulphur or sulphur-containing gases. It should never be



A dance floor of glass in a smart night spot. Now it appears that glass can be used for most everything.

glazed into an opening until *all* other work has been completed. For the best service life this glass should be laminated between polished plate glass cover glasses, to protect the surfaces.

Prolonged exposure to X-ray at voltages materially over 100 Kv. will produce a distinct brown discoloration, which is without effect on the protection value, but may ultimately interfere with vision. At voltages of 200 Kv. and over, the discoloration is rapid and may become intense. When multiple layers of X-ray lead glass are required for adequate protection, they should be laminated together in the manner of Hi-Test Duplate (Sec-

tion C). Where exposed to direct X-ray, as opposed to scattered, the layer of X-ray glass nearest the tube should be easily replaceable, independently of the other layers of this multiple assembly.

X-ray lead polished plate glass is available in photographic quality and protective quality.

X-ray lead polished plate glass is especially suited for use as a protective covering for valuable documents and for this purpose is marketed in document quality which is extremely carefully selected for this use.

Curators of museums and libraries have for



Rough glass Herculite in roof and valance make this dining porch an attractive haven. No fear of dropped objects here.

years sought a clear flat glass which will afford both maximum visibility and adequate protection against light rays which cause deterioration of parchments, letters, etc. Experiments conducted by the Swedish National Testing Institute in Stockholm have shown the ultra-violet rays to be the most destructive of various papers and inks, and the value of the protection furnished depends upon the exclusion of the ultra-violet.

SOLEX (HEAT-ABSORBING) POLISHED PLATE GLASS

The name Sorex was given to this polished plate glass product to indicate that its primary function is to exclude solar heat. It accomplishes this purpose to a remarkable degree by absorbing within itself a large portion of the incident solar energy, while at the same time it transmits di-



Going behind the scenes "through the looking glass." A smart night club depends on mirrors to decorate distinctively.

rectly far the larger portion of solar light. It will exclude from 30 per cent to 40 per cent of the total incident solar energy and will transmit from 70 per cent to 75 per cent of the total visible white light. It intercepts most of those rays which are harmful to fabrics, dyes, etc. Rooms in which the windows are exposed to direct sunlight and are glazed with Solex, will be from 10°F. to 15°F. cooler than if they were glazed with normal glass.

Solex has a pleasing blue-green color, which tends to soften the color tone of out-of-doors objects. It largely absorbs the blues and reds, while freely transmitting yellow and green. It intercepts a large portion of the ultra-violet and tends to delay the deterioration of fabrics, dyes, etc., exposed to direct sunlight.

Solex Polished Plate Glass may be silvered to produce an unusual aquamarine mirror which



A desk and table top of heavy polished plate glass provide a businesslike working surface and add an air of distinction to this office.

lends itself to modern ideas of interior decoration, either as a wall mirror, table top or plaque.

It is especially useful in the glazing of airport control towers, fire control towers in the U. S. Forest Service and other observation equipment.

It is obtainable in $\frac{1}{8}$ inch, $\frac{1}{4}$ inch and $\frac{3}{8}$ inch thicknesses. The $\frac{3}{8}$ inch thick product has the same absorption and transmission properties as the $\frac{1}{4}$ inch while the $\frac{1}{8}$ inch product which is especially designed for control tower glazing is materially more absorptive than the other thicknesses.

See Section J for the general physical and mechanical properties of this and other glass products.

Solex is a regular soda-lime-silica glass to which approximately 0.6 per cent of ferric oxide has been added. The iron is reduced to the ferrous state as far as possible to absorb the solar infra-red heat energy.

There is a distinct difference between heat-absorbing glasses and heat-resisting glasses. The terms are not at all synonymous. A glass may be both heat-absorbing and heat-resisting, but it does not follow that a heat-absorbing glass is a heat-resisting glass, nor conversely. Most heat-resisting glasses are of the boro-silicate type, typified by Pyrex Glass. They will withstand high temperatures and direct flame and are characterized by their low coefficients of expansion.

Heat-absorbing glasses may be of any com-

position which includes materials opaque or partially opaque to a major part of solar—or other—radiant energy and which tend to become hot when exposed to sunlight, almost regardless of surrounding atmospheric temperatures. Thickness: $\frac{1}{8}$ inch, $\frac{1}{4}$ inch, $\frac{3}{8}$ inch. Maximum size 124 inch x 143 inch; 124 inch x 218 inch and 72 inch x 165 inch, respectively.

BLUE POLISHED PLATE GLASS

Blue polished plate glass finds its principal use as a mirror. It is highly decorative and is equally well suited for use as wall, panel or special framed mirrors, as well as for table tops, plaques, etc. Blue polished plate glass mirrors emphasize the blues and violets and subdue the flesh or reddish colors. They are especially suitable for use in the boudoir to “make up” by artificial light for an afternoon party, or elsewhere where natural light will be the principal source of illumination.

Blue polished plate glass has exactly the same composition as regular polished plate glass, except that a very small percentage of cobaltic oxide has been added to the melt. It is obtainable only in $\frac{1}{8}$ inch thickness while the maximum size is 124 inch x 195 inch.

FLESH TINTED POLISHED PLATE GLASS

Flesh tinted polished plate glass, used as table



This large picture window provides a wall mural in Nature's seasonal colors, and would enhance the livableness of any home.

top, bureau cover, etc., produces an apparent warmth of color and enhancement of the beauty of the wood beneath it not obtainable with any other glass. As a mirror it is especially effective in softening and toning down colors reflected from it. The reflected image gives one a sense of good health and well-being. When used in the boudoir by daylight it will assist milady in making up most satisfactorily for the opera or other evening functions where artificial illumination will predominate.

The color of flesh tinted polished plate glass is obtained by adding selenium oxide to the melt. The only available thickness is $\frac{13}{64}$ inch, and the maximum size 124 inch x 195 inch.

TAPESTRY GLASS

Tapestry glass is an excellent example of the unexpected which sometimes results from research and development programs. In the evolution of the continuous process of producing plate glass from tanks, cast-iron or steel rolls of many differ-

ent compositions were tried out to determine maximum life, proper construction, etc. Among them was one particular cast-iron formulation which after some days' use developed a continuous nonrepetitional pattern of indeterminate design, resulting from contact of the roll surface with the molten glass. The design or pattern was very similar on both the top and bottom rolls, but materially deeper or stronger on the bottom roll. It was also found that rolls of this same composition always produced an indistinguishably similar pattern—and Tapestry glass became an article of commerce, $\frac{7}{32}$ inch thick, by a maximum of 60 inch x 144 inch.

POLISHED TAPESTRY GLASS

Polished Tapestry glass is produced by grinding and polishing the smoother surface of the plate. It is widely used where an obscure glass is desirable, particularly in office partitions. The high light transmission values of polished Tapestry warrant its use wherever light without trans-

parency is required. It is obtainable in $\frac{7}{32}$ inch thickness only, and in maximum size up to 60 inch x 140 inch.

UNPOLISHED PLATE GLASS

In general, rough plate glass is available in thicknesses from $\frac{3}{16}$ inch to $\frac{5}{16}$ inch greater than the corresponding finished polished plate glass product. The surface texture varies from one factory to another. Usually the bottom surface, as rolled, is very much more uneven than the top surface, which may present a watered silk appearance, or may be nearly as rough as the bottom. In some instances the top surface presents a knurled appearance. None of these unpolished plate glass products, with the single exception of Tapestry, should be classed among the configured or other rolled and figured glasses.

Heavy rough plate is particularly useful as flooring, and is used extensively in libraries and other similar structures.

BRACKET SIZES

In the very nature of the product, it should be obvious that large sizes of any grade are more difficult to obtain and consequently more expensive than smaller sizes. However, plate glass is not marketed in standard sizes, but may be procured in any dimensions required, within maximums. The multiplicity of prices which would result if each of the millions of possible combinations of length and width were separately listed must be avoided. The first step in reducing the amount of calculation was to establish even inch (2 inch, 4 inch, 6 inch, etc.) cutting, which at once eliminates more than 80 per cent of the total possible number of sizes, fractional dimensions being considered as the next higher even inch. Then certain groups of sizes, called brackets, were established on the basis of the number of square feet and fractions of a square foot in a plate. A table giving the number of square feet for all full inch dimensions from 1 inch x 1 inch to 239 inch x 120 inch known as The Decimal Plate and Sheet Glass Calculator, will be found in every warehouse and individual copies may be obtained through usual Company channels.

The brackets for plate glass are: under 1 sq. ft.; 1 sq. ft. (including 12 x 12) to 2 sq. ft.; *2 to 2'8"; *2'8" to 5 sq. ft.; 5 to 7; 7 to 10; 10 to 15; 15 to 25; 25 to 50; 75 to 100; 100 to 120; 120 to 140; 140 to 160; 160 to 200; 200 to 240 sq. ft. Plate glass is sold to the jobber principally on the basis of these

bracket sizes. However, glass is distributed to the general trade on the basis of a price list which is set up for even inch dimensions in 2 inch increments for all sizes from 6" x 6" up to 138" x 208"; 140" x 204"; 142" x 202" and 144" x 200".

QUALITIES

Plate glass is furnished in one or another of three grades which are known as Silvering, Mirror glazing and Glazing qualities. Mirror glazing quality is invariably used where the highest standard of glazing is required and imperfections are discovered only on close inspection. This quality is rarely sold for glazing purposes in sizes over twenty-five square feet. Glazing quality represents the usual selection of plate glass supplied when quality is not otherwise definitely specified. Silvering quality is seldom required for glazing purposes.

Of necessity, allowable tolerances in quality must vary considerably with the size of the sheet required, and accordingly, Federal Specification DD-G-451, Glass: Flat for Glazing Purposes, provides for four separate specifications according to size. For present purposes, however, it will be sufficient to define the qualities for sizes up to and including 10 square feet and for sizes from 10 square feet to 25 square feet inclusive.

Sizes up to and including 10 square feet

Silvering quality—This quality must not contain any major defects. The central area of this quality may contain well scattered fine seed and short, faint hairlines, when not grouped, and occasionally very light short finish visible only on close inspection. The outer area, in addition, may contain seed and short, faint streaks when not grouped.

Mirror Glazing—This quality may contain scattered seed, faint hairlines, and light short finish. The outer area, in addition, may contain short streaks and occasional faint strings not over 2 inches long. The edges may contain coarse seeds, but none shall be longer than $\frac{1}{32}$ inch in diameter.

*The dimension 2'8" is an anachronism carried over from an earlier day when superficial areas were calculated in square feet—inches—and parts. In this system, the area in square inches, divided by 144 gives square feet as the quotient, the remainder from that division divided by 12 gives inches as the quotient, and the remainder would be called parts. For example, a plate 16" x 24" has an area of 384 sq. in. This would be 2 feet—8 inches—0 parts; while 389 sq. in. would be 2 feet—8 inches—5 parts. All areas are now computed in decimals and in the examples above, the areas would be 2.6667 sq. ft. and 2.7013 sq. ft., respectively.

The polish must be good, and essentially free from visible short finish.

Glazing quality—The central area of this quality may contain numerous scattered seeds, including an occasional coarse seed, but not heavy seeds. Small bubbles may occur on the edge. Stones, large bubbles, skim, pronounced ream, or long or heavy scratches are not permissible. Faint strings and light ream in the corners or upper edge of the light are permissible. The polish may show areas of short finish.

Sizes from 10 to 25 square feet, inclusive

Silvering quality—The central area of this quality may contain more numerous fine seed than the small sizes, short, faint hairlines, and occasionally light short finish. The outer area may contain occasional coarse seed and short faint scratches when not grouped.

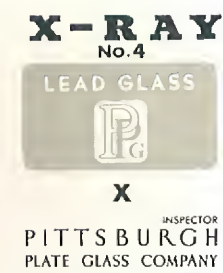
Mirror Glazing quality—The central area of this quality may contain more numerous fine seeds and light short finish than the small sizes

and an occasional coarse seed. The edges may contain occasional small bubbles and fine strings. No heavy defects or scratches which can not be removed by buffing are permissible. The polish must be good but some visible short finish may occur.

Glazing quality—The central area may contain small bubbles and fine strings or ream which does not give visible distortion when looking straight through the glass, but no long or heavy scratches. The edges may contain bubbles over $\frac{3}{32}$ inch, visible scratches shorter than 10 inches, small areas of ream, strings, and small stones not larger than $\frac{1}{32}$ inch, but these defects should not be grouped or interfere with the vision. The polish over the central area should be good, but patches of short finish may be present about the edges.

General—None of the above grades or sizes may contain any heavy or long lines, heavy streaks of ream, any bubbles larger than $\frac{1}{8}$ inch, visible short polish, large open bubbles, areas of skim, or stones over $\frac{1}{32}$ inch in diameter.

A RANDOM GROUP OF LABELS AS APPLIED ON PLATE GLASS



B-2

CARRARA STRUCTURAL GLASS

EIGHT STANDARD COLORS OF CARRARA

(PRINTED COLORS DO NOT ILLUSTRATE LUSTER OR TONE DEPTH)



WHITE



BLACK



IVORY



BEIGE



TRANQUIL GREEN



FOREST GREEN



GRAY



REMBRANDT BLUE

TWO TRIM COLORS OF CARRARA



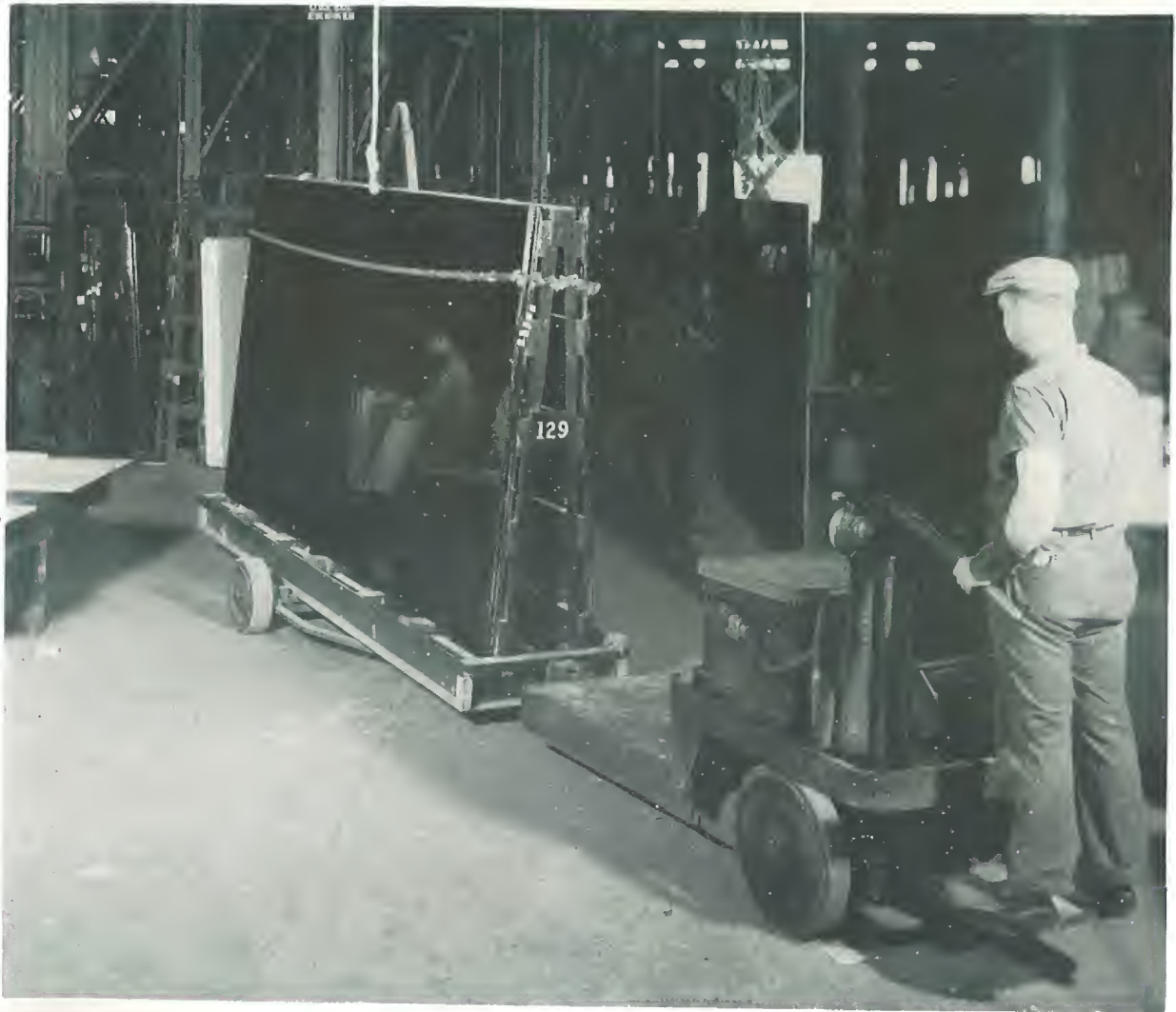
ORANGE



WINE

Carrara Structural Glass

Opaque glass has been manufactured by the Pittsburgh Plate Glass Company since about 1900. Originally it was made in white only, resembling so closely the white marble of the Carrara quarries of Italy, that the glass was appropriately called Carrara, and the name was retained later when black and colored opaque glasses were added to the line.



A traffic jamb in the Carrara Department storage racks.



Carrara wainscot and toilet stalls combine with open doorways and mirrors to enhance the view.



Walls will always be beautiful in this modern Carrara kitchen.

CARRARA is made up of a mass of crystals suspended in a matrix of glass, so that when one looks at a piece of Carrara, one actually looks into the glass, which accounts for the depth of color not obtainable in a coated surface. With Carrara, it is the body of the material which is of interest, therefore the surface of Carrara is ground and polished to reveal the interior of the sheet, and to permit one to see beneath the surface. The ground and polished surface is, of itself, a beautiful feature of Carrara.

Generally, the Carrara Glasses are ground and

polished on one side only, although some of the heavier thicknesses, which are used in special applications, are also available with both sides ground and polished.

Carrara Structural Glass is produced at Works No. 6, Ford City, Pennsylvania, by the same kind of equipment used in the manufacture of heavy plate glass—by the pot melting process. The manufacture begins with the preparation and melting of the batch, followed by the casting of the molten glass, annealing, and the final step of grinding and polishing the rough product as it comes from the lehrs.

After leaving the grinding and polishing machines, the plates are thoroughly washed by a hand cleaning operation to remove any adhering plaster, rouge, etc., rather than by the acid wash which is customarily used in the plate glass plants. From the wash racks the glass goes to the examiners, who mark any surface defects for the guidance of cutters. The glass is then ready for the wareroom storage racks, as stock sheets.

Within the same limits applying to polished plate glass fabrication, i. e., the finishing of the edges, beveling, grinding, polishing; decoration of surface, sandblasting, special surfacing, etc.; preparation of glass for installation in the field, drilling of holes, cutting notches, etc.; is handled in the fabricating and decorating department of Works No. 6, which is the most interesting, and certainly the most active division of the plant. Some of the processes used are peculiar to Works No. 6, and all of them are described in Section F. The department occupies an immense room with special equipment—grinding wheels, sanding belts, polishing wheels, sand grader and circular grinding tables.

Carrara Glass may be bent to shapes or forms. In general, this work is within the limitations imposed on polished plate glass of the same size and thickness, as described in Section C.

Slabs of Carrara can be laminated by a method of permanently cementing the sheets together under heat and pressure so that the unit may be handled and used in the same manner as solid glass. The laminated Carrara slab surpasses all other types of materials for toilet partitions. Cement lamination of Carrara Glass must not be confused with laminated safety glass described in Section C—it is not a safety glass.

The tempering process, by which Herculite is made, Section C, may also be applied to Carrara, producing Herculite Carrara, materially increas-



This bathroom utilizes Carrara, Mirrors, shower door and tub enclosure for long lasting beauty that is easily maintained.

ing its strength and resistance to high temperatures (650°F.) and to sudden changes in temperature (450°F. thermal shock).

In general, the Carrara Glasses may be classified with the basalts and feldspars. All except black belong to the family of soda-alumina-silica glasses, which are opacified principally by the addition of sodium-silico-fluoride to the melt. This compound tends to become milky while the glass is being annealed, due to the action of the fluorine, which has an opalizing, opacifying effect. Actually, the colors are variations of the white batch.

(1) White Carrara, the original product—a soda-alumina-silica glass, opacified with sodium-silico-fluoride.

(2) Tranquil green, the same composition as white with chromium, cobalt and nickel.

(3) Ivory, obtained when selenium and iron

are added to the white batch as the colorants.

(4) Gray, obtained when nickel, cobalt and selenium are added to white batch.

(5) Beige, selenium is added to the white batch, as the colorant.

(6) Wine, the white batch plus cupric oxide.

(7) Forest green, the white batch plus chromic oxide, calcium fluoride and cuprous oxide.

(8) Rembrandt Blue, cobalt, nickel and calcium fluoride, plus the white batch.

(9) Orange presents some deviation from the basic soda-lime-silica mixture. It is a soda-potash-alumina-silica glass, opacified with sodium-silico-fluoride and colored by the addition of cadmium-sulphide and selenium.

(10) Black Carrara is an entirely normal soda-lime-silica glass to which the coloring agents manganese and chromium have been added in con-

siderable amounts. Manganese absorbs certain portions of the spectrum, and chromium absorbs certain other portions. Both of these oxides are oxidizing agents in the glass melt, and tend to maintain in the ferric condition any iron which may be present. The intensity of color is so great that black Carrara is entirely opaque to visible light in thicknesses over $\frac{1}{4}$ inch. If an intense light source is placed behind a piece of black Carrara $\frac{1}{4}$ inch thick or less, a very considerable portion of the visible red light from the light source will

be transmitted by the glass. It is highly transparent to the infra-red in all thicknesses and infra-red photographs may readily be made through it. Black Carrara is actually a very deep red-purple color, and is not opacified in the sense that the other Carrara Glasses are opacified.

Carrara Glass is shipped from Ford City as stock sheets, approximately 72 inch by 130 inch or cut to size as ordered, in all the colors, also white and black, which are available in thicknesses and in special surface finishes as follows:

	White	Black	Ivory †Tranquil Green Gray	Blue Beige Forest Green	Wine Orange	Net Weight Lbs. Per Sq. Ft.	Shipping Weight Lbs. Per Sq. Ft.
$\frac{1}{4}$ " Pol. 1 side		CS				3.29	4
$\frac{1}{4}$ " " 2 sides		CS				3.29	4
$1\frac{1}{32}$ " " 1 side	CSA	CSA	CSA	CSA	C	4.5	5
$\frac{7}{16}$ " " 1 side	CS	CS	CS			5.76	$6\frac{1}{2}$
$\frac{3}{4}$ " " 1 side	CS	CS	†CS			9.67	12
$\frac{7}{8}$ " " 1 side	CS	CS	CS			11.51	15
$\frac{7}{8}$ " " 2 sides	°	°	°			11.51	15
$1\frac{1}{4}$ " " 1 side	C	C	C			16.45	20
$1\frac{1}{4}$ " " 2 sides	°°	°°	°°			16.45	20

C—Available in cut sizes.

S—Available in stock sheets.

A—Ashlars of standard 8" x 16" and 16" x 16". Ashlar sizes range 8" x 8" to and including 24" x 24". Minimum dimension 8", maximum dimension 24", whole inches only. See Section D-5, Structural Units.

°Structural Units, partitions. See Section D-5, Structural Units.

°°Stiles, lintel, etc. See Section D-5, Structural Units.

†Tranquil green not available in $\frac{3}{4}$ inch thickness.

Stock sheets are packed in cases containing approximately the following square feet per case: $\frac{1}{4}$ "—500'; $1\frac{1}{32}$ "—500'; $\frac{7}{16}$ "—375'; $\frac{3}{4}$ "—250'.

SUEDE FINISH, standard in all colors in $1\frac{1}{32}$ inch thickness only. This is a soft, velvety surface, obtained by special treatment of the glass under the polishing process. Surface texture diffuses the light so as to reduce reflection approximately 45 to 75 per cent, depending on the color; yet does not distort or blur the subdued reflections.

HONED FINISH, available only in black in all thicknesses except $\frac{1}{4}$ inch. Has a smooth, ground, nonreflecting grayish surface, without semblance of polish.

SANDBLASTED, obtained by blowing sand against the glass by means of compressed air. The degree of surface roughness may be varied by using sand of various grades of coarseness, changing the air pressure and varying the distance between nozzle and glass. Sandblast is used also to carve designs by use of masking stencils of a rubber-like material.

The characteristics of Carrara Glass determine its range of use. Some of these characteristics are peculiar to glass alone; some are possessed by glass to a greater degree than by other comparable materials.

Carrara Glasses are impervious to moisture,

stains and odors. Therefore, uses where sanitation is imperative are suggested; viz., hospital, kitchen and restaurant walls and equipment, wainscot in bathrooms, laboratories, food processing establishments, toilet partitions and wall work in public toilet rooms. As the surface of



Mirrors, Black Carrara and Aluminum combine to beautify this theater foyer. This beauty will endure.



A typical stove splash installation is easy to keep clean.



Carrara walls and Mirrors lend charm to this bath.

Carrara is ground and polished, it is favored for counter tops, deal plates and work surfaces of many kinds.

Soon after its introduction, the sanitary properties of Carrara Glass were recognized, and it readily gained favor as a substitute for marble table tops and many other uses where its beauty and utility established preference for Carrara Glass. A logical use was in toilet rooms as wainscots and partitions.

The first large installation of Carrara Glass was in the Woolworth Building, New York City, in 1912 and 1913. The job was so well executed and so completely vindicated the judgment of the Architect, Cass Gilbert, that throughout his life, he advocated the use of Carrara Glass in toilet rooms.

Other architects, great and small, soon followed Mr. Gilbert's ideas, and Carrara Glass became a standard specification for toilet room walls and partitions, toilet compartment fronts or stiles.

There developed about 1921 a trend toward complete store fronts of glass: facia, bulkheads, pilasters and upper sign panels of Carrara with polished plate glass show windows set in metal store front fittings.

The modernization of "Main Street" with new or remodeled stores for customer eye-appeal began in 1934 with an array of colors of Carrara and polished plate glass set in Pittco metal, comprising a complete tailor-made line of new and beautiful store front setting members of extruded alumilited aluminum and bronze.

Carrara Structural Glass is one of the most useful, intriguing and versatile of the Company products. The wide choice of colors permits ready adaptation to almost any color scheme and opens wide the portals to creative artistry in design. The range of available thicknesses of these structural glasses enables the architect or engineer to use glass of adequate strength for the purpose in hand. Variations of surface finish may be adapted and combined in almost infinite variety.

Carrara Glass presents the true surface perfection found only in polished plate glass products. The polished surface has a depth of finish which produces a satisfying sense of esthetic value. Kitchens—bathrooms—powder rooms—boudoirs—may be given a distinctive air of glamour and charm quite in keeping with the modern trends in interior decoration. Carrara panels appropriately decorated, either intaglio or in relief or severely simple, carry out the general motifs of the scheme of detail both in color and design.



Sculptured black Carrara wainscot depicting the skilled artisans of the automotive industry.



Mirrored reflections of an edge lighted sculptured half inch plate over a black Carrara panel—distinguish these private drawing rooms in a famous club.



Carrara supplants steel in the lining of many types of conveyor chutes.

The glass may be used either as ashlar or in larger sizes as may be desired.

Walls of Carrara Structural Glass in bathrooms and kitchens provide obvious and easily appreciated advantages which are not offered by any other building material. The easy-to-clean surface and attractive colors are a never-ending source of real satisfaction.

The Carrara bathroom and kitchen may be adapted to practically any building budget, from the inexpensive ready-built treatments to the more elaborate installations involving the entire wall areas and ceilings.

Structural units—ashlar and trim—are especially useful in this field, since they have been specifically designed for the purpose. Use of ashlar in the wall areas provides many satisfying design possibilities. Carrara base, door and window trim, window sills and shelves further enhance the maintenance-free features provided by the installation of other structural units.

Signs and decorative features of Carrara are a



An excellent example of the use of Carrara as a professional man's "shingle."

must in store front work. The long-lasting, attractive appearance of these units is a valuable asset to any commercial organization. These signs are of two types: laminated and sandblasted, or a combination of the two.

The laminated sign panel consists of a Carrara Glass background to which Carrara letters of various types and sizes are laminated or cemented. Letters, trade-marks or design features of virtually any character may be produced. The all-glass construction is obviously superior, since the colors cannot fade and the sign is easily cleaned with a damp cloth.

The sandblasted sign is prepared by sandblasting the letters or design into the glass about $\frac{1}{16}$ inch deep. The blasted area is given a prime coat and enameled. Bronze, aluminum and gold leaf are used with equally satisfactory results. As with the laminated treatment, design possibilities are limitless. Decorative panels produced by this process are frequently used in bathroom or powder-room installations.

Permanent beauty and freedom from maintenance combine to make the Carrara plaque a very attractive medium for honor rolls and war memorials, small signs and directories. Various treatments are possible: sandblasted letters, painted or unpainted, or raised letters where the background is blasted. Borders, seals, trade-marks and decorative features may be sand-carved and executed in gold leaf.

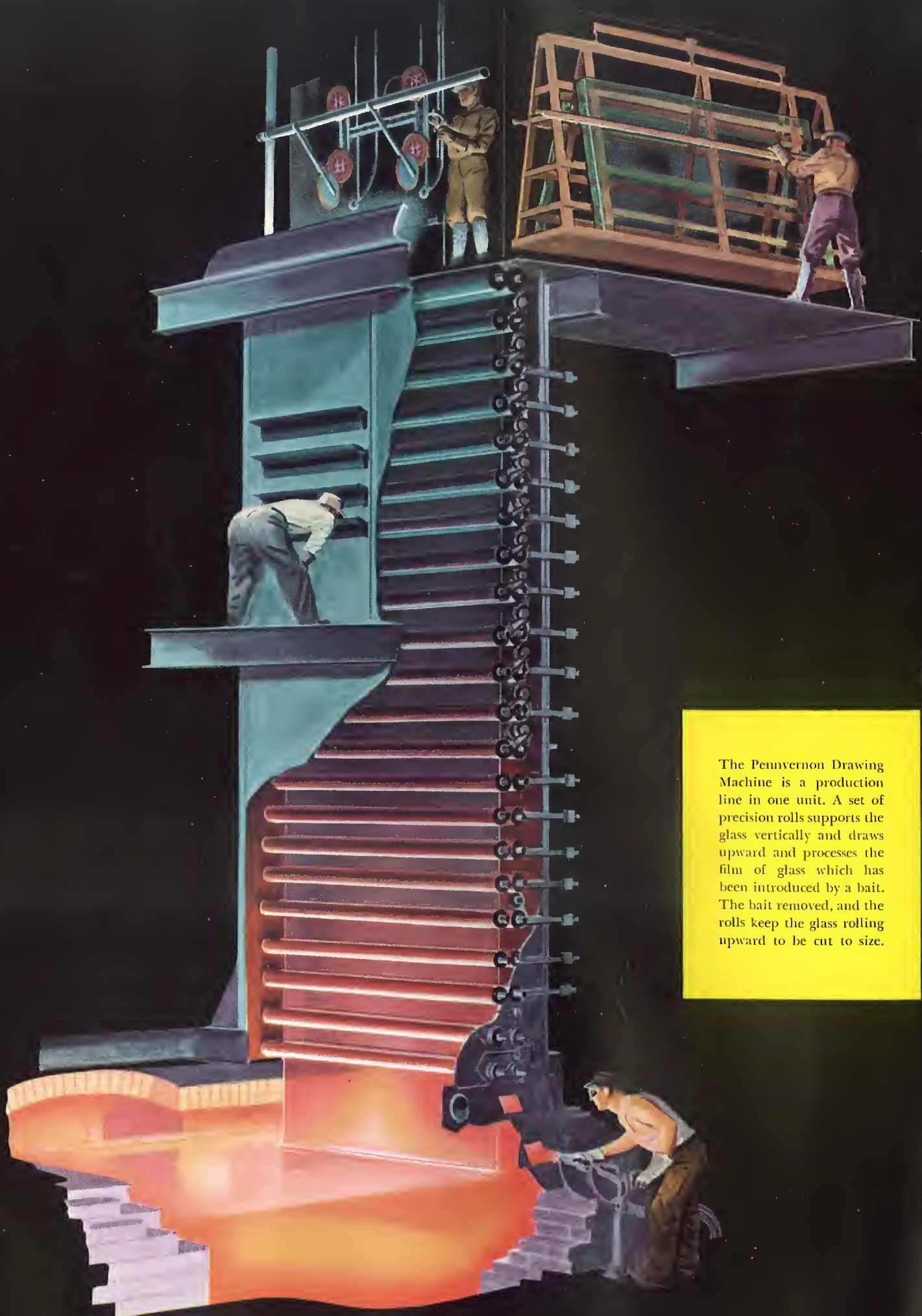
The richness of color throughout the glass insures a permanence of decorative value which is enhanced by the almost indestructible character of the surface.

The surface remains beautifully brilliant. The surpassing resistance of Carrara Structural Glass to deterioration from exposure to dirt, moisture, chemicals, oils, pencil marks, insures a minimum maintenance cost. It may be kept clean by occasional use of a damp cloth.

Carrara Glass is a quality material. Its merit as a combined decorative and structural material has created a great demand for its use as fascia of store buildings, for sign panels, or wherever such material may serve. On the other hand, Carrara Glass can be glamorous—for dressing-table tops, coffee tables, cocktail trays, book ends, pen bases, decorative wall plaques. Carrara Glass is versatile.

B-3

PENNVERNON FLAT DRAWN SHEET GLASS



The Pennvernon Drawing Machine is a production line in one unit. A set of precision rolls supports the glass vertically and draws upward and processes the film of glass which has been introduced by a bait. The bait removed, and the rolls keep the glass rolling upward to be cut to size.

Pennvernon Flat Drawn Sheet Glass

The superior quality flat drawn sheet glass marketed by the Pittsburgh Plate Glass Company under the name Pennvernon is produced in its finished form by drawing vertically from a free, open bath of molten glass as a continuous flat sheet.

WHILE NOT differing greatly from plate glass in composition, the essential difference is that plate glass surfaces are plane and parallel because they have been ground and polished during fabrication; while the drawn sheet surfaces are produced as a brilliant fire polish as the sheet is being formed. As a result of differential contraction as the sheet is cooling, there is some unevenness of surface. This has been greatly improved in recent years, yet the product still lacks the perfection of polished plate glass.

The production of glass for glazing purposes extends well back into history and the early processes, as may be expected, were crude and laborious and the product useful mainly for light transmission, but not for clear vision.

In the early period, attempts to make common window glass by the flat casting process ended in complete failure.

While glass-blowing was an ancient art, its

first application to the production of window glass in the United States is recorded about 1800 in the making of what was called crown window glass. The method, which originated in Europe, entailed the gathering of a gob of molten glass on the flanged end of a blowpipe with a mouthpiece at the other end for the blower, who would blow the plastic glass into spherical formation. An iron rod, called a punty, with a dip of hot molten glass, was attached to the glass bulb opposite the blowpipe connection. The pipe was then removed, leaving a sizable opening in the sphere. After reheating the glass to a limp consistency, the punty was spun in a whirling motion to cause the glass to form a flange or disc.

The removal of the punty left a glass sheet from which pieces of glass could be cut to small window pane dimensions. The center of the disc containing the bulls-eye is still highly prized for its decorative effect.



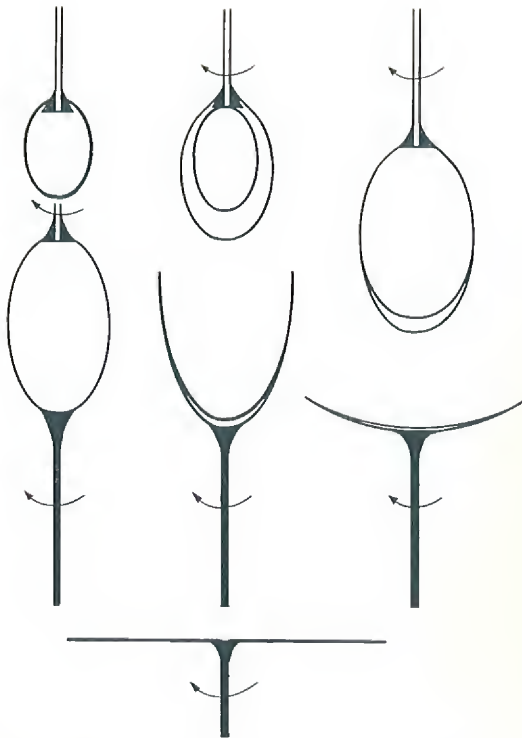
Works No. 12 nestles among the hills at Clarksburg, West Virginia, to produce a steady stream of Pennvernon window glass.

The limitation to small lights, the high cost and inferior grade of quality marked the epoch of crown window glass production.

The first large scale method for producing common window glass commercially was the blowing of cylinders by what was known as the Hand Process, with subsequent splitting and flattening of the cylinders. Glass was made in pots or in a tank furnace and was gathered into a plastic ball on the end of a hollow blowpipe by an operator known as a gatherer. The pipe, with the attached gather of glass, was then passed on to an operator called a blower, who applied his mouth to the open end of the pipe and by blowing was able to start the formation of a hollow sphere, much as a soap bubble is blown. By the nature of the gather and the manipulation by the blower, the sphere on the end of the pipe was made to elongate into a cylinder with the unformed balance of the original gather at the closed end. By reheating the unformed mass at intervals at

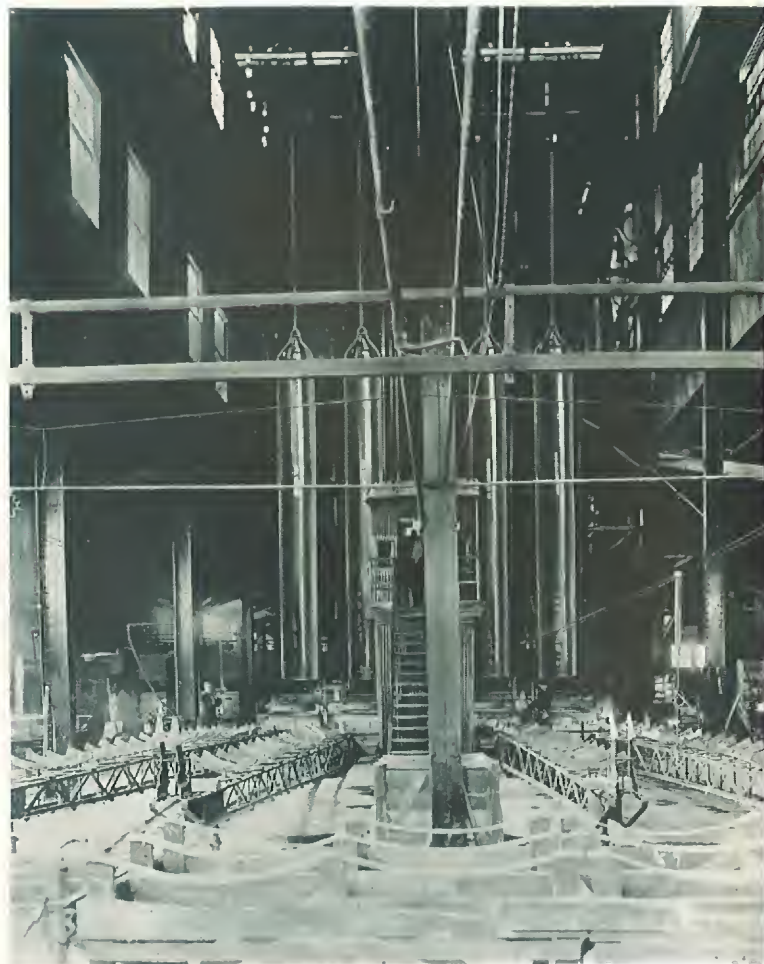
the "Glory Hole" in the furnace, so that it remained plastic, maintaining the air pressure in the cylinder already formed while swinging it like a pendulum in a pit beneath the working floor, the ball of glass at the end of the cylinder was made to elongate itself with continuous uniformity into a cylinder of glass of the desired diameter and thickness. The two ends of the cylinder were cut off by wrapping a thread of hot glass around each end of the cylinder and touching the heated area with a cold iron; thus effecting a cut. The cylinder or roller thus produced was of maximum diameter of approximately 20 inches and about 6 feet long.

The cylinder was then split longitudinally and placed in an oven on a clay flattening stone. The split cylinder was advanced through zones of increasing temperature until it had softened enough that the oven operator or flattener, could unfold the cylinder and produce a relatively flat sheet by ironing over the surface with a heavy



The evolution of Crown Glass from original gather to finished disc. The center of the disc is the much sought after Bulls Eye glass.

The Cathedral of Glass—The blowing room of a cylinder window glass factory.



wooden flattening block. The sheet thus formed was then allowed to cool slowly and was cut into lights of the desired sizes by the cutter.

Due to the severe working conditions, the hand plants usually operated seasonally from about the first of September to the first of May.

Because of the natural division of the different stages in the process, there arose a number of craft unions—the gatherers, the blowers, the flatteners and the cutters. Although entirely interdependent, these groups were often in conflict. As the process became mechanized, first the gatherers and blowers and then the flatteners passed out of the window glass operation.

At best, the hand-blown glass was poor according to modern standards. The glass itself was ordinarily not well made: the gatherer introduced cords; the glass was battered in appearance because of repeated cooling and reheating; the glass was not uniform in thickness; and the flattening process introduced sand marks, burn, and other marks from the flattening tools.

In the course of time, the hand-blown cylinder of window glass evolved into the machine-blown cylinder with the elimination of the gatherers and the blowers. The cylinders were drawn vertically from a kiln or pot by means of a long, mechanically operated blowpipe through which compressed air was introduced. It had a baiting device on the end for contacting the molten glass and starting the cylinder. The glass cylinder was drawn vertically 30 to 40 feet, supported only by the blowpipe, the bottom of the cylinder was cut free, the open-end cylinder lowered to the horizontal by means of mechanically operated equipment which was called a take down, and the pipe removed. When in the horizontal position, the two ends of the long cylinder were trimmed off as in the case of the hand-blown roller. This operation was accomplished with an electrically heated wire instead of a glass thread. The cylinder was then cut into a number of shorter cylinders and the smaller cylinders in turn were split lengthwise into two or more sections known as shawls,



Glory hole, blowing pit, glass blower and helper illustrate the Hand Process of window glass making. This was exhausting work in the earlier days.



according to the diameter of the cylinder. These shawls were flattened as previously described.

The size of cylinders produced by this method increased the maximum from 18 to 20 inches diameter by 6 feet long of the hand-blown cylinder to 40 inches in diameter by 40 feet long. This mechanical process was not seasonal and was carried on throughout the year. The hand-blown window glass plants grew fewer in number and practically disappeared about 1925.

The machine-blown window glass improved in quality because the continuous tank furnaces produced better metal and the gathering process was eliminated. The machine-made cylinder was more uniform in thickness. Flattening was improved somewhat, but burn was often evident and the sheet always retained a certain amount of crown or belly.

In 1908 the Pittsburgh Plate Glass Company bought the Chambers Window Glass Company factory at Mt. Vernon, Ohio. This factory was converted from the hand-blown cylinder method

The Chambers Window Glass Company factory at Mt. Vernon, Ohio, produced window glass by the Hand Process.

Shawls awaiting cutting and flattening in the old Mt. Vernon plant.



The batch house at a window glass factory differs but little from that at a plate glass factory, in keeping with the similarities of the products.

to the machine-blown cylinder method. Two tank furnaces were put in operation. Each furnace had kilns for simultaneously drawing 12 cylinders mechanically. This factory became Works No. 11.

In March, 1917 the Pittsburgh Plate Glass Company completed the construction of a new factory at Clarksburg, West Virginia. This factory duplicated the machine cylinder operation at Mt. Vernon, Ohio, and became Works No. 12.

Another step in sheet glass production was already apparent. Fourcault, in Belgium, designed a machine to draw a flat sheet vertically by gathering from an elongated pool of molten glass extruded from a slot in a clay block immersed in the bath of molten glass. This sheet is conveyed upward continuously through a metal casing by a series of pairs of asbestos covered rolls.

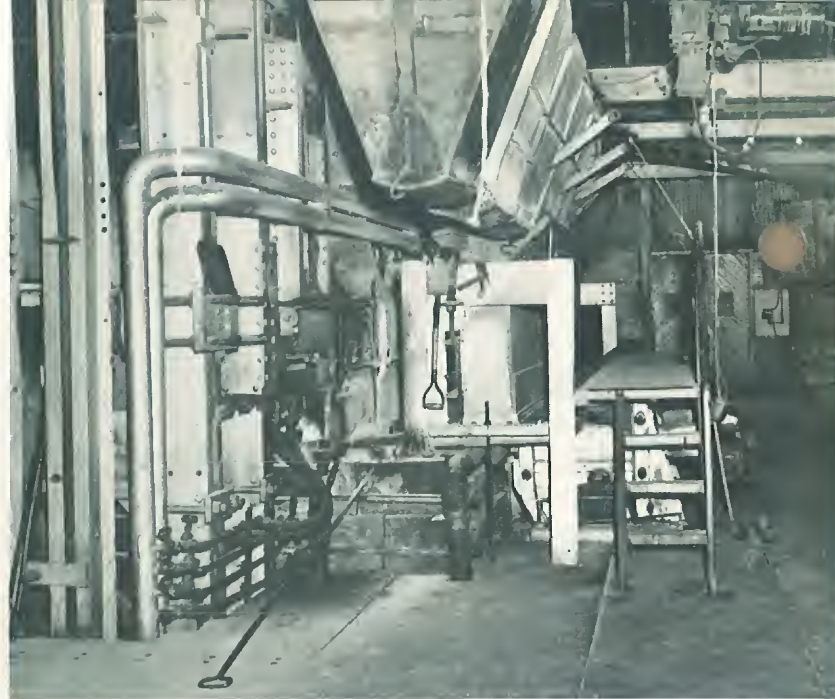
Then the Colburn Process appeared. The sheet, in this case, is drawn from molten glass supplied to a shallow pot from a continuous melting furnace. After a vertical travel of about 24 inches, the sheet is bent over a roll and is conveyed on a series of rollers through a horizontal lehr.

About the year 1918, Harry G. Slingluff, Superintendent of the Mt. Vernon, Ohio, factory, obtained patents on a process for vertically drawing

a continuous flat sheet from an open bath of glass over a submerged clay bar. The first vertical conveyor for this continuous sheet was a pair of asbestos cloth belts. In the course of developments, the drawing kiln was enclosed and the asbestos belts were replaced with a vertical lehr, through which the sheet was conveyed by asbestos-covered rolls.

The evolution of the Pennvernon process to its present stage of development was a long, difficult and, at times, discouraging task. Success was achieved by the combined efforts of the Engineering Department, the Research Department and the splendid day-by-day contributions of the management and workmen of the factories. Needless to say, back of all this were the Company Executives whose foresight, interest and encouragement made the project possible.

Commercial production of flat-drawn sheet window glass by the Pennvernon process was started at Works No. 11 at Mt. Vernon, Ohio, in 1925, and in 1927 the process was put into operation at Works No. 12 at Clarksburg, West Virginia. In 1928 construction of the third Pennvernon factory was started at Henryetta, Oklahoma. This factory came into production in 1930



Good housekeeping in the weighing department of the batch house.
The Pennvernon process is a remarkably clean operation throughout.

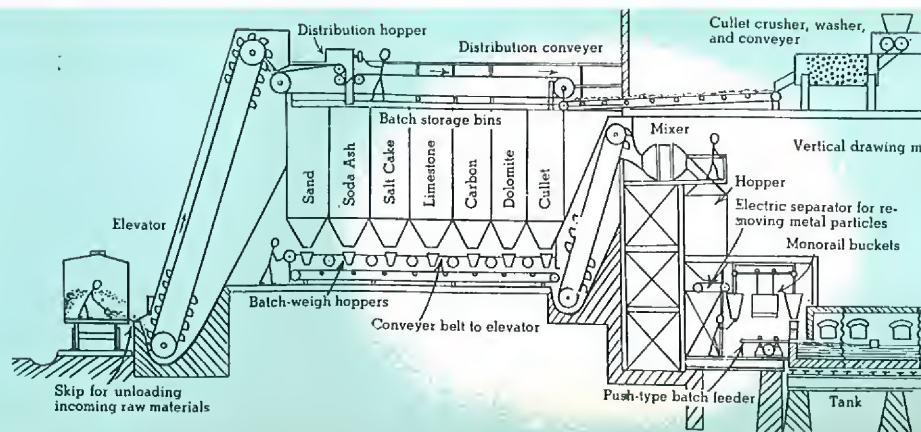
and became Works No. 10 of the Pittsburgh Plate Glass Company. Each factory has 2 large tank furnace units, with an additional smaller experimental unit at Works No. 12. Each large tank unit is equipped with 4 drawing machines.

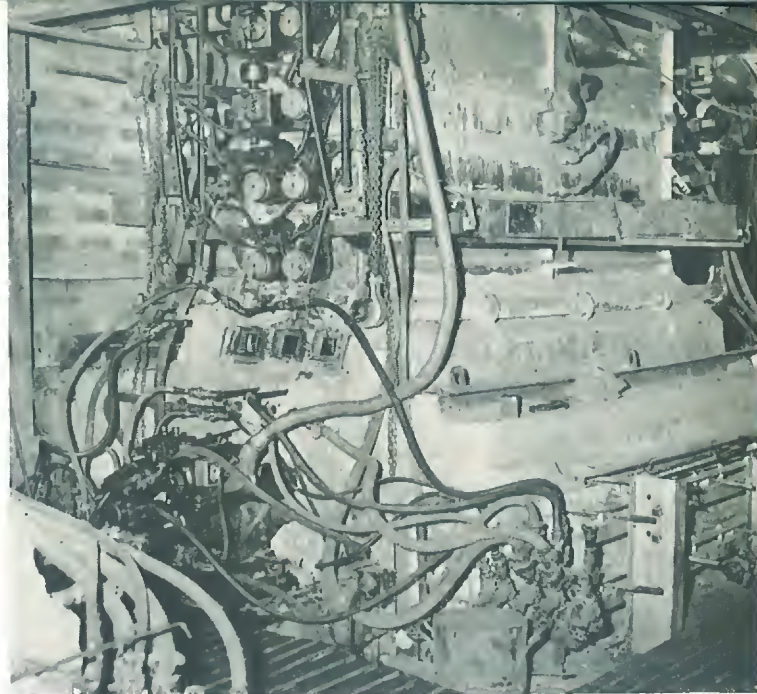
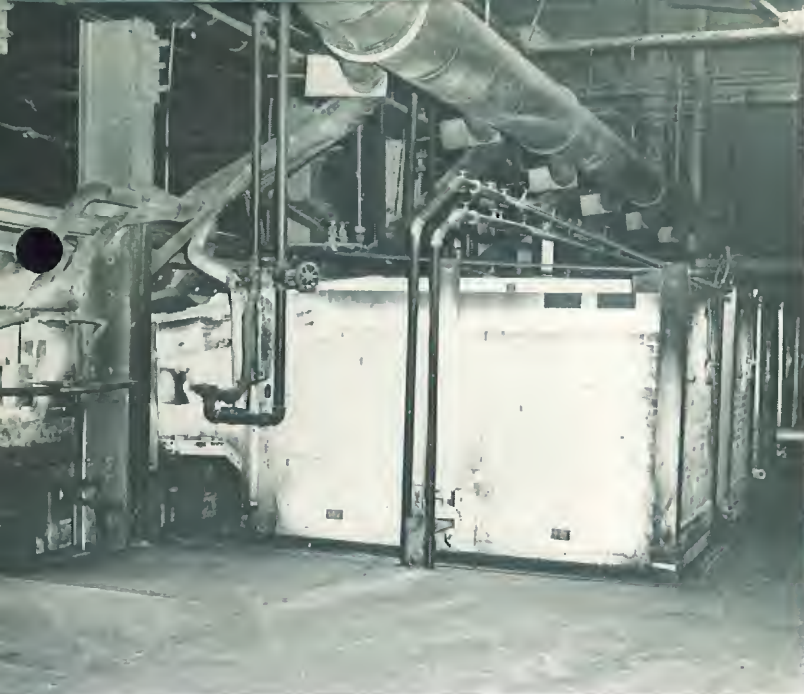
The raw materials in Pennvernon are: glass sand, soda ash (sodium carbonate), limestone (calcium carbonate), dolomite (calcium carbonate and magnesium carbonate), salt cake (sodium sulphate), feldspar (sodium potassium aluminum silicate), carbon and cullet (crushed glass). These materials are mixed in proportions according to a formula developed during the years to produce a glass that can be well refined in the furnace, will not devitrify (crystallize) in the drawing kilns, has the desired viscosity at drawing temperatures to make high drawing speeds possible and has chemical durability and resistance to weathering or staining which is satisfactory for all commercial purposes.

The various raw materials are received in carloads and stored in large, adjacent silo-type concrete storage bins.

In preparing the glass batch, the various materials are drawn from the bottoms of the storage bins through very accurate weighing hoppers and are conveyed to a large mixer for intimate mixing. The individual mix or charge, weighing about 3 tons, is drawn off from the mixer on a belt conveyor, passes over a powerful magnetic separator to remove tramp iron and then by means of splitting baffles, the flow of batch is evenly divided into 3 monorail buckets. From the batch house, the buckets of batch are conveyed by monorail to a position over the continuous automatic feeder which introduces the batch into the furnace. This arrangement of handling the batch prevents unmixing and subsequent poor quality of glass in the furnace, and finished sheet.

The Pennvernon tank furnaces are similar to the plate glass tank furnaces. They are gas fired and of the regenerative type, which means that the flames travel across the hearth and the direction of travel is alternated at regular intervals. The exhaust gases, on their way to the stack, pass through chambers packed with fire-brick which





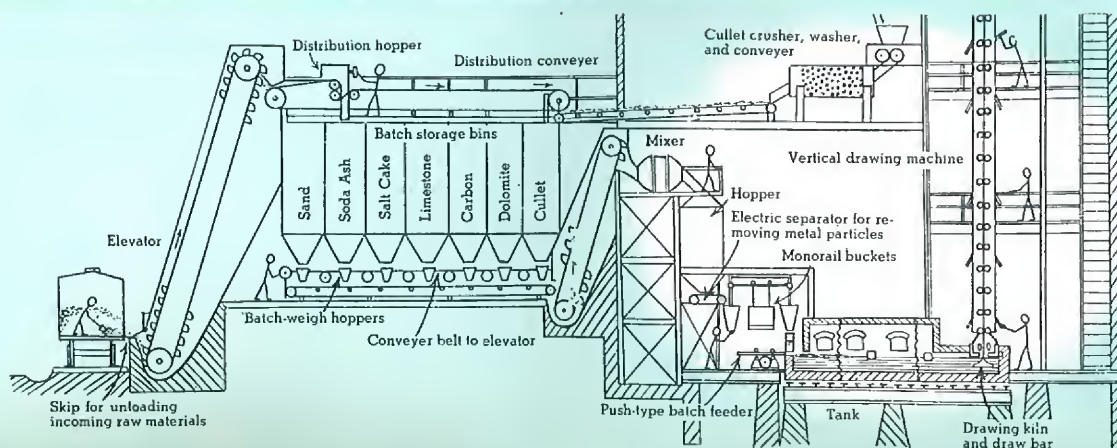
A corner of the tank itself adjacent to the drawing machine. The drawing machine is highlighted below on the floor diagram.

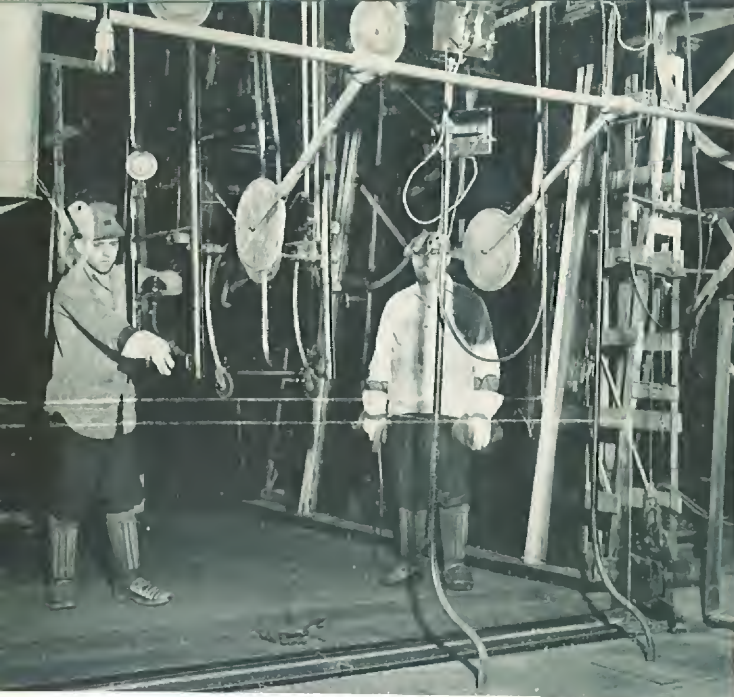
absorb much of their heat. This heat is recovered by the combustion air which enters the furnace on the alternate part of the cycle when the exhaust gases are passed out through the other set of chambers on the other side of the furnace.

The basin of the furnace is constructed of special refractory blocks. Not unlike a large swimming pool, this basin is continuously full of molten glass (1,400 tons) which circulates from the hot end to the colder end as a result of normal heat convection movements. Over the basin is supported a crown of silica brick which is arched across from side to side. The entire furnace structure is bound together with vertical steel buckstays which are tied together at the top and bottom by horizontal steel tie rods. The flames enter the furnace through a series of ports in the vertical walls between the basin and the crown or cap and play across the hearth; the waste gases exhaust through corresponding ports on the opposite side of the tank. The flames cover about half the area of the basin from the end at which the batch is charged.

The prepared batch is charged continuously at the fired end, and a corresponding amount of glass is drawn out at the other end. The batch material floats on the molten glass and melts as it progresses from the charging end. At about midway of the fired area, the last of the batch has melted and shortly after that the foam, which has resulted from the melting of the batch, also disappears. As the glass continues to flow under the remainder of the fired area, the residual gas bubbles leave the surface and by the time the end of the fired area is reached, the glass is fully homogeneous and refined. From this point to the drawing machines the glass is uniformly cooled to a suitable temperature for drawing the sheets. This temperature reduction is accomplished by radiation loss from the furnace, assisted by a curtain wall which extends across the furnace above the glass to the crown at the end of the fired area. Clay floaters extending across the basin to a depth of about 18 inches in the glass under a curtain wall also assist materially in reducing glass temperature by controlling convection.

SECTION B-3 • 9





A continuous ribbon of glass emerges through the floor to be cut into stock sizes and moved to the wareroom.

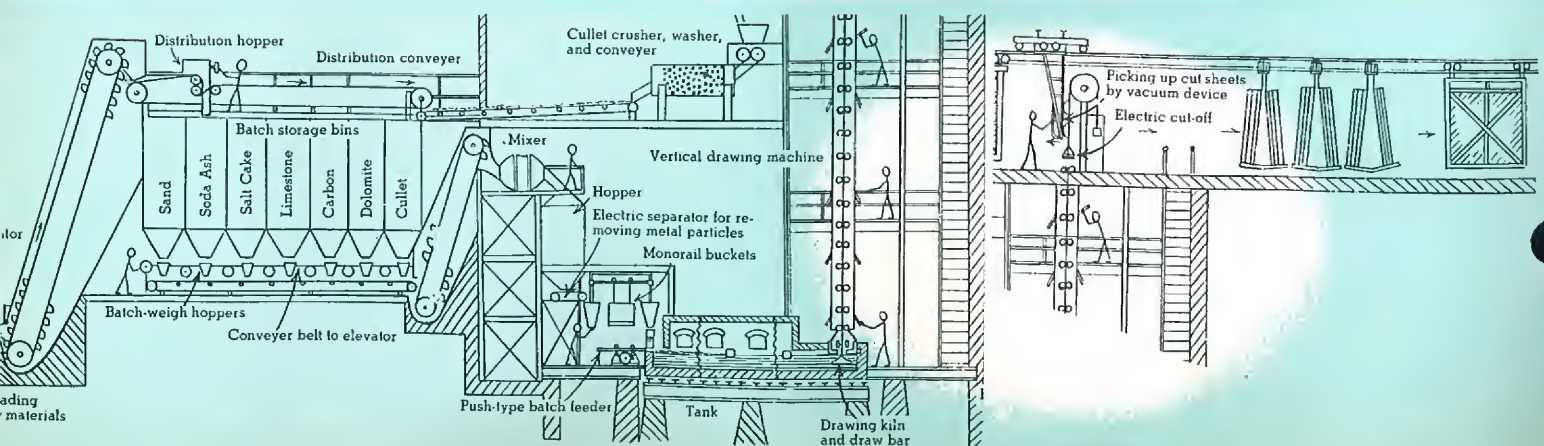
The glass is drawn from the surface of each of 4 bays or kilns grouped about the working end of the tank—one on each side and two on the end. These kilns are of the same depth as the tank basin and are fully open to the tank basin except for a clay member, called a shut-off block, suspended across the kiln where it joins the tank basin. This shut-off block is immersed about 15 inches in the glass and seals off the hot gases of the tank furnace chamber above the glass from the drawing kiln chamber.

The drawing kilns are enclosed by refractory shapes suspended over the front and back. Over the center portion and about 2 inches above the glass, are suspended two ell-shaped clay pieces (ell-blocks) with the horizontal members extending toward each other. The openings at the ends between the ell-blocks are closed with removable doors and the combination constitutes the sheet drawing chamber. Between the ell-blocks a 27 inch width of glass bath is exposed. A clay draw bar of horizontal slab shape with a longitudinal rib on the top face is submerged several inches below

the glass surface in the drawing kiln. The glass sheet is drawn from the glass surface immediately over the rib of the draw bar. The submerged draw bar serves to regulate glass temperatures in the drawing kiln, to control the convection flow of the glass and to assist in defining the line of generation of the sheet.

The drawn sheet is supplied from the surface of the bath and surface glass is replenished by glass that flows into the drawing kiln from the tank basin. As the glass flows into the drawing kiln, part of it rises to the surface between the shut-off block and the draw bar, and part passes under the draw bar and rises between the draw bar and the front of the kiln. By virtue of the design of the shut-off block and the location of the front kiln wall, convection currents in the vicinity of both the shut-off block and the front wall cause the surface glass in the kiln to flow toward both of these members. As a result, no glass drawn into the sheet has pulled off a refractory surface and line and cord defects, which result from such a condition, are eliminated. This

SECTION B-3 • 10





Window glass is examined, cut to size and stacked in sized piles all in small examining and cutting booths in the wareroom. Note how the workman holds the cutter.

is one of the several marked advantages of the Pennvernion process.

The drawing machine is suspended over the center of the exposed area between the ell-blocks and extends vertically about 25 feet above the drawing kiln. It consists of a steel housing, or lehr, in which are mounted pairs of horizontal asbestos-covered rolls, at intervals of 12 inches. The back roll of each pair has its bearings rigidly mounted, while the front roll is suspended from a counterweighted arm, which provides traction to draw the sheet while the yielding pressure of the self-adjusting roll allows a flexibility conforming to the requirements of the drawing operation.

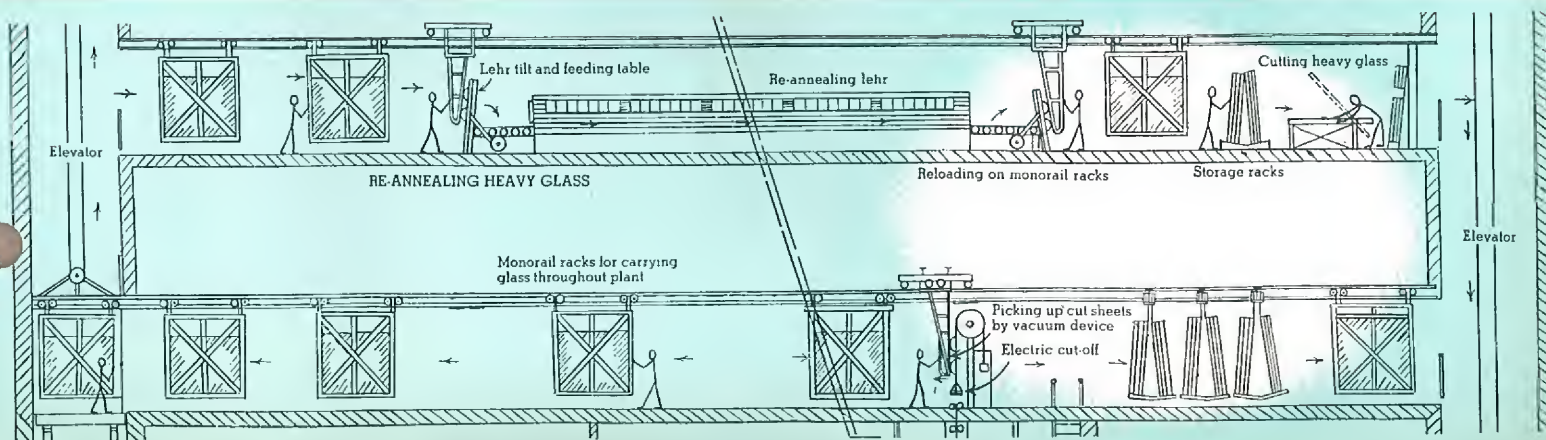
The floor on which the drawn sheet is delivered from the top of the machine is called the Cut-Off floor. Intermediate between the drawing room floor and the cut-off floor are 2 balconies which surround the end of the tank structure and serve to give access to the 4 drawing machines during the drawing operation.

The start of the draw is accomplished by means of a bait. This bait is a frame of flat steel bars

about the width of the sheet to be drawn with heavy wire loops attached at the bottom. The bait is inserted in the top of the drawing machine with the rolls turning in reverse direction and is lowered until the wire loops are submerged in the glass in the kiln. The glass closes over the loops and anchors to the wire. The rolls are then reversed and as the bait rises a sheet of glass rises with it and continues to be generated from the surface of the bath. As soon as the glass sheet is gripped by the rolls in the drawing machine, the bait is no longer needed and is removed from the top of the machine. The sheet continues to be generated by the traction of the rolls in the drawing machine. That a sheet can be drawn from a pool of glass, is the result of inherent properties of glass and the special composition of the batch.

As glass cools it gets more viscous or stiff. At 1400°F. it is quite viscous, but can be drawn. At 1200°F., stretching still continues, but between 1200°F. and 1100°F., all appreciable stretching has stopped and the glass has become rigid. The glass leaves the bath at about 1400°F. in a fairly

SECTION B-3 • 11





Standard Pennvernon crate boxes and special cases are used for the shipment of Pennvernon window glass. A box contains fifty square feet of window glass.

thick mass which continues to stretch, but loses heat rapidly as it is divorced from the hot pool and is exposed to the cooling effect of water-cooled steel boxes extending across the kiln adjacent and parallel to the sheet. The stretching action tends to narrow the sheet, but suitable devices are supplied at each edge to maintain sufficient side pull to keep the width.

After the sheet becomes established, there is no contact until the sheet has set to rock hardness and is no longer in danger of being marred by the drawing rolls; the brilliant fire polish of the molten glass is preserved.

The incomparable finish, or surface luster, so distinctive in Pennvernon Flat Drawn Sheet Glass, is the reward of vigilant effort in maintaining the natural finish of the glass as the sheet is formed to the stage where plastic deformation of the sheet can no longer occur.

In the Fourcault method, the plastic glass is extruded hydrostatically through a forming member and bears the imprint of this treatment.

In the Colburn process, the sheet travel is

changed from the vertical to the horizontal by bending over a roll while the glass is still plastic, leaving discernible evidence of permanent surface distortions from contact with the roll.

In the Pennvernon drawing process, the following features are unique:

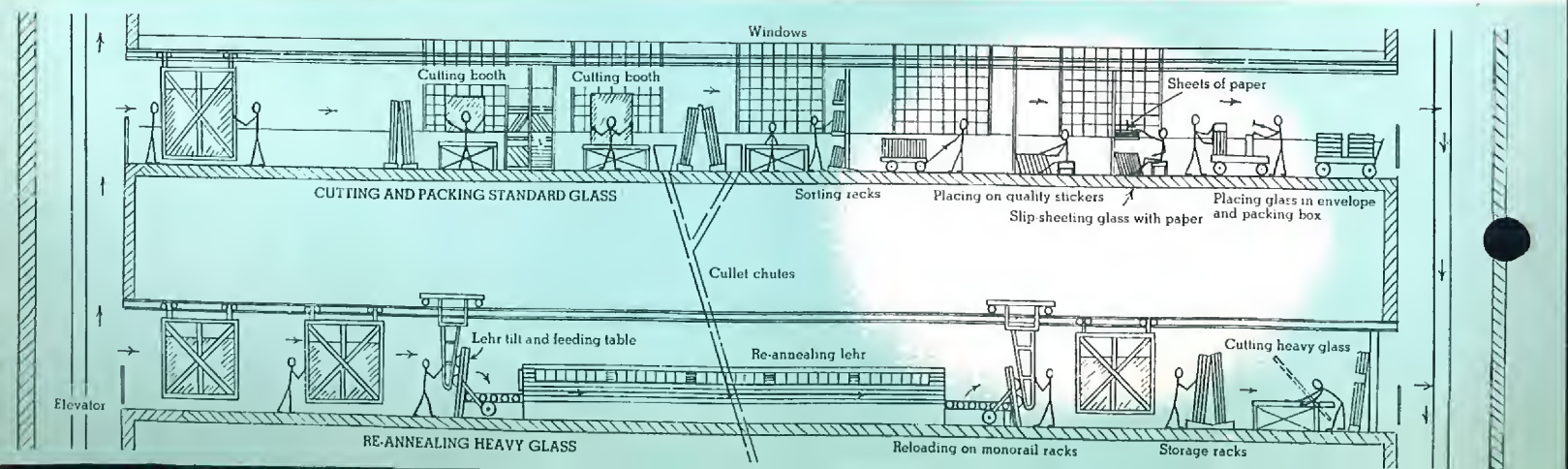
1. The sheet is drawn from a free, open bath with no possibility of contamination from clay or other refractory surfaces.

2. The drawn sheet is not contacted *on either side* until the surfaces are set beyond danger of being marked.

3. Improved means of temperature control during the sheet forming process have produced a sheet of unmatched flatness and freedom from visual distortion.

Different thicknesses of sheet are produced by varying the speed of draw—the slower the speed the heavier the sheet, and vice versa; faster drawing produces thinner sheets.

As the sheet progresses upward it cools and, at the top of the machine, is ready to be severed into sheets of the desired size. The edge portion





These illustrations disclose the proper procedure in opening and re-packing a box of Pennvernon Window glass. Note the corrugated paper carton and the light wood crate.

which has been marked by the edge forming device must also be removed. Both of these operations are mechanically done by ingenious automatic equipment. The sheets are set up into packs weighing 3,000 to 4,000 pounds for transfer to the cutting room by overhead monorail cranes.

In the cutting rooms the packs are transferred to the cutters' stalls. Here the glass is graded and cut to order by the cutters working in individual stalls on felt-covered tables equipped with pin bars, squares and straight edges. These cutters constitute the only trade union surviving from the hand cylinder days. They still cut glass principally with the diamond and train their own apprentices, as of old.

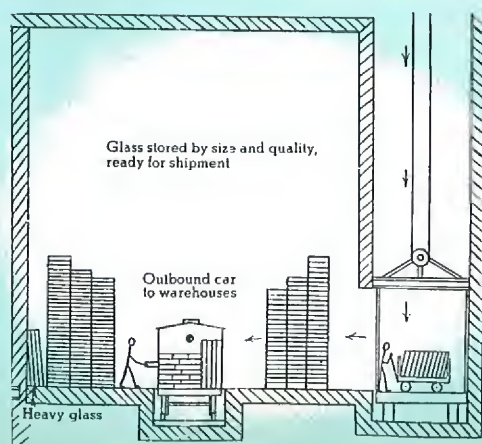
The glass, which has been graded, cut and assembled, is counted off as 50 foot boxes by the cutters. A staff of inspectors rigidly examine it

for cleanness, squareness of cutting and for defects in the glass and on its surface. After inspection the glass is labeled according to grade and thickness and interleaving paper is placed between all lights to prevent scratching, to absorb moisture and to preserve the surface. The Pennvernon label on every light of this product bears the works number of the producing factory and serves as a guarantee of quality standard, recognized by architects, builders and the trade.

Thus labeled and separated by thin paper of full size, the glass is ready for packaging.

The Pennvernon method of packing has great merit for safety against breakage in transit, adaptability for storage and handling, unpacking and repacking.

The glass to be packed, usually fifty square feet to the box, is encased in a corrugated carton of





A label that identifies the leader in window glass. Grading and labeling glass must be accurate, dependable and consistent.

proper size, snugly fitted into its crate and the lid nailed tight. The box is stamped showing the thickness and quality of the glass, the packer's initials and date.

Ample stocks of packed glass in popular sizes are normally maintained at all Company factories, warehouses and stores.

The ease with which Pennvernon may be packed or unpacked as necessity dictates is shown in the series of photos reproduced.

It should be noted that the inside corrugated carton makes an ideal pocket for the glass as it comes from the box with the paper which should remain between every light for the dealers' glass storage racks.

Clear Window Glass is a transparent, flat, relatively thin glass having glossy, fire-finished, apparently plane and smooth surfaces, but having a characteristic waviness of surface which is visible when viewed at an acute angle or in reflected light. Practically all clear window glass is made by drawing directly into a flat sheet, the

surface finish being that obtained during the drawing process.

Thickness and Quality—Clear window glass for glazing is made in several different qualities and in the varying thicknesses—Photo, Picture Glass 16 oz., Single Strength, Double Strength, $\frac{3}{16}$ inch Heavy Sheet and $\frac{7}{32}$ inch Heavy Sheet, shown in Section J-3. Single strength and double strength window glass is regularly supplied in two standard qualities, known as A quality and B quality. A limited amount of this glass, known as AA quality, which is especially free from defects, is sometimes selected for special purposes and may be specified if desired. The production of AA quality is limited. Double strength glass is also produced in a quality known as greenhouse quality. The amount of glass produced in this quality represents a very small percentage of the total window glass produced.

Dimensions—Window glass is cut to dimensions ordered with an allowable tolerance of plus or minus $\frac{1}{32}$ inch.



Windows are an important element in a home like this. Their formal arrangement demands fine quality window glass and glazing. Pennvernon enjoys this distinction.

AA Quality—The defects permitted are only the slightest or minute imperfections and must be almost imperceptible.

A Quality—The defects permitted in this quality are fine sheen or light burn, a few small seeds if not too prominent, and a very light scratch detected only by close scrutiny. No light shall contain all of these defects and those present may not be clustered. Sizes above the first 3 brackets, owing to the lights being larger, will permit a few more of the above defects providing general appearance of the glass is clean. In general, the central area of light shall be practically free from defects and the appearance of the light as a whole shall be such that there is no perceptible interference with the vision as long as one is looking through the glass at a distance of 36 inches and at an angle greater than 30° with the face of the glass.

B Quality—Permits defects such as blisters not more than ½ inch long in the marginal area of the light, some seeds (more prominent than permitted in A quality), faint lines, a sheen or burn, and

dirt specks that are not too coarse. With all these defects as a combination, there must not be the resemblance of coarse grading. Sizes above the first 3 brackets, owing to the lights being larger, will permit a few more of the above defects provided the general appearance of the glass is clean. The appearance of the light as a whole shall be such that there is no perceptible interference with the vision as long as one is looking through the glass at a distance of 36 inches and at an angle greater than 45° with the face of the glass.

Greenhouse Quality—Comparable to B quality double strength. Packed only in sizes: 16 inch by 18 inch, 16 inch by 24 inch, and 18 inch by 20 inch. This glass is of selected quality for greenhouse glazing, without defects that might concentrate the rays of the sun and injure growing plants.

Heavy Sheet Glass in selected quality and factory run quality shall be graded according to the standards set up for A single and double strength and B single and double strength window glass, respectively, except, due to the heavier



A neat bay window for charm—or hundreds of windows for efficient daylighting and ventilation. Architects unhesitatingly specify Pennvernon Window Glass.

thickness, the allowable inherent defects would appear proportionately more numerous.

Brackets—All window glass is classified as to size and area by brackets. The brackets covering picture, single and double strength glass are based on united inches; i.e., the sum of the *length and width* of the light of glass. The standard brackets for these 3 thicknesses are as follows:

Picture Glass	Single Strength		Double Strength		
25"	50"	70"	90"	105"	120"
34"	51"	80"	94"	110"	
40"	60"	84"	100"	115"	

Heavy sheet glass is not furnished in widths over 76 inches nor in lengths over 120 inches.

Heavy sheet glass is classified on the basis of *square foot areas*. The standard brackets for heavy sheet glass are as follows:

1' and under	7'–10'
1'–2'8"	10'–25'
2'8"–5'	Over 25'
5'–7'	

Grouping window glass by brackets is based upon the fact that the larger the size of the glass, the greater the cost per unit of area. Rather than to fix slight cost differentials between the tremendous number of sizes, it is more practical to adopt the relatively few graduated changes by means of brackets. To illustrate:

Picture, single or double strength glass, 10 inch by 22 inch in size, or 32 united inches, is in the 34 inch bracket—12 inch by 26 inch or 38 united inches in the 40 inch bracket—18 inch by 36 inch or 54 united inches in the 54 inch bracket, and would be priced higher than glass in the lesser brackets, etc.

Packaging—Normally, window glass is packed in boxes containing 50 square feet, as nearly as the particular glass size will permit, in all brackets up to 100 united inches. Brackets of 100 united inches and over, are packed in 100 foot boxes.

Heavy sheet glass, $\frac{3}{16}$ inch and $\frac{7}{32}$ inch, in cut sizes is packed in boxes of 50 square feet. Stock sheets are packed in cases containing approxi-



A modern plant glazed in the current lateral light manner. Here glass becomes a tool for the architect. Note the uniform appearance of the reflections in the windows.

mately 300 square feet. Stock sheets are not supplied in sizes under 10 square feet in area.

AVERAGE BOX WEIGHTS

Kind	50' Box	100' Domestic	100' Export
Picture	48 #	96 #	96 #
Single Strength	68 #	135 #	140 #
Double Strength	90 #	185 #	200 #
$\frac{3}{16}$ " Heavy Sheet	135 #	285 #	300 #
$\frac{1}{32}$ " Heavy Sheet	150 #	315 #	325 #

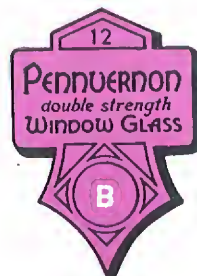
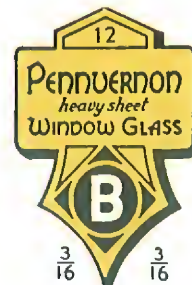
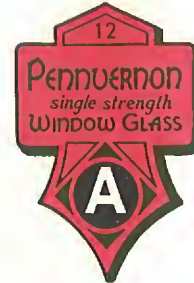
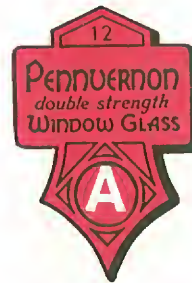
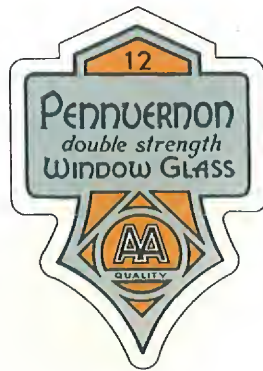
Fractional Cutting—The factory cutters' wage scale is calibrated in full inches, hence there is an extra cost for cutting fractional sizes. This cost is based on either 1 or 2 fractional cuts as the case may be. For example:

A light 12 inch by 16½ inch would require 1 fractional cut.

A light 12½ inch by 16½ inch would require 2 fractional cuts.

The standard unit for recording sheet glass production is the so-called box, which is a package containing the nearest number of lights of any particular size which will make 50 square feet. The capacity of a window glass tank furnace is usually given as so many boxes and for comparative purposes, the amounts of all strengths produced are converted to the equivalent unit of 50 square feet of single strength and the capacity is given as single strength equivalent.

A RANDOM GROUP OF LABELS AS APPLIED TO PENNVERNON WINDOW GLASS

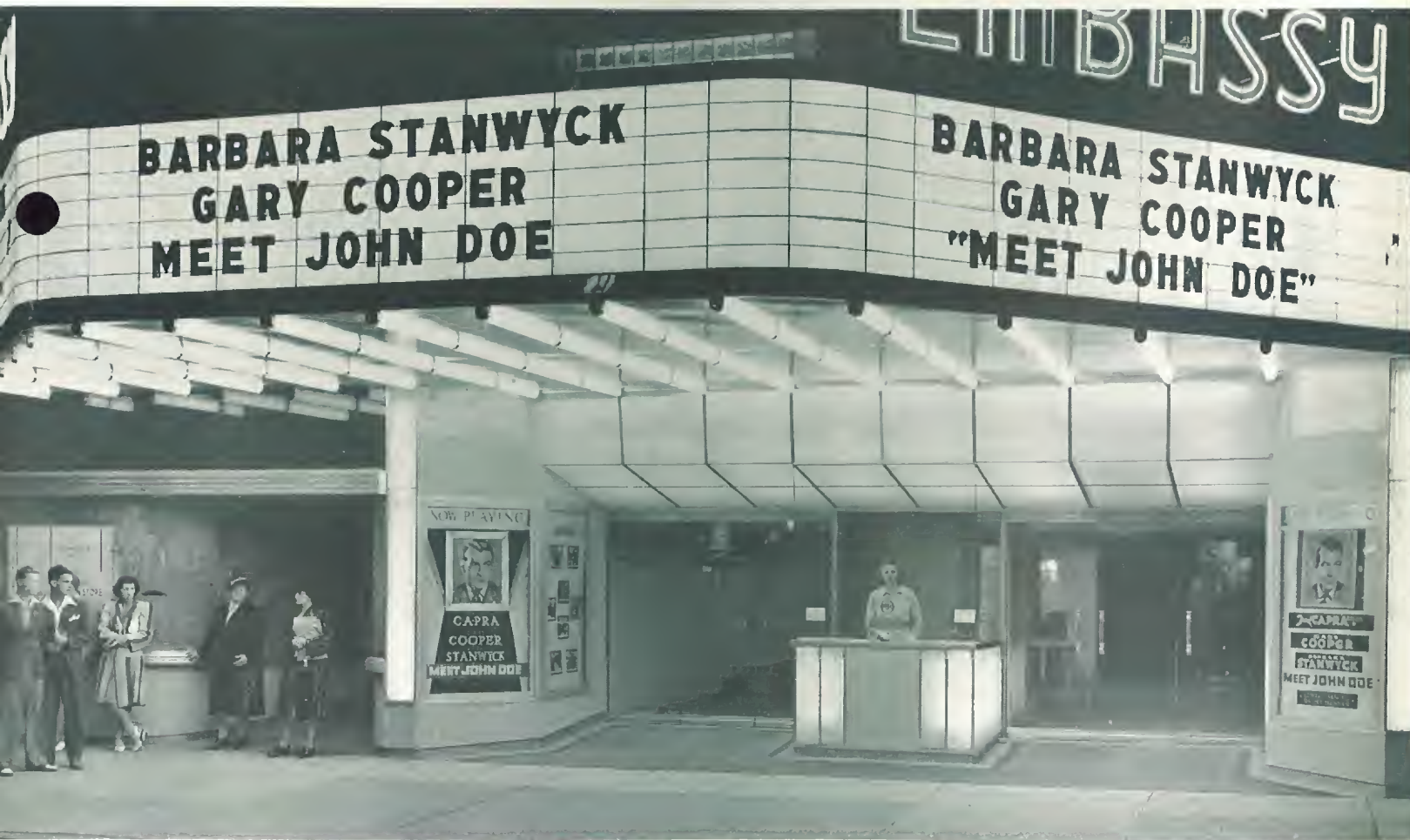


B-4

PITTSBURGH LIGHTING GLASSES

Pittsburgh Lighting Glasses

From the earliest days when man first made glass and learned to shape it, glass has played a large part in the make-up of lighting fixtures and equipment.



Bright lighting illuminates the entrance of a movie palace. The current attraction is advertised on the backlight marquee.



A directors' table gets its proper foot candles from the specially designed fixtures and fluorescent tubes in the ceiling.

THE EARLIEST uses of glass in lighting equipment were as enclosing tubes around flaming wicks, to protect the feeble flame against sudden drafts of air. The whale-oil lamps of early American history, the tallow candle of a still earlier date and the kerosene lamps of modern times all depended upon glass wind guards to maintain a stable, unflickering, if feeble, illumination.

The advent of the carbon arc lamp shortly followed by the incandescent electric lamp greatly increased the overall usefulness of glass as an indispensable aid in the practical and decorative applications of light.

The magnificent chandeliers of the days of Louis XIV and of the resplendent era of ostentatious display in America with their innumerable pendant glass prisms, should also be considered a part of the utilization of glass in illumination.

Mirrors have long been used to enhance the apparent brilliance of illumination and to reflect light about a room. Pieces of flat, colored glass were used in the early developments of theatrical spotlights. These uses formerly constituted very nearly the sole applications of flat glass to illumination through light sources other than daylight.

Flat glass in windows, essentially an illuminating material, does not immediately enter the picture in the sense in which we are here discussing lighting glasses.

All light, whether from natural or other sources, has always carried with it a concomitant impression of heat and to some small degree glass, both flat and specially shaped, has been used to exclude the heat developed by man-made lighting sources from the area being illuminated.

Through the years it has been appreciated that cold light was possible. The firefly, the phosphorescent sparks produced by the disturbance of the ocean waves in tropical climates, the glow of decaying stumps in the forest and the pale shimmer of some phosphorus compounds all give evidence that cold light actually is obtainable.

It has often been said that "What man can conceive, man can achieve" and man-made cold light is today becoming a very real and increasing factor in the lighting of our homes, offices and factories. With the discovery of the X-ray, it was also discovered that certain compounds exposed to the utterly invisible X-ray would become themselves visibly luminescent. These materials are



Bent panels of lighting glass add a decorative touch. These units are especially made to use the modern fluorescent tube.

generally classed as phosphors. It was subsequently found that many phosphors would react to ultra-violet radiation which is much closer to the range of the visible spectrum than is the X-ray. Electric discharges within a tube containing mercury vapor produce a large proportion of invisible ultra-violet radiation along with some very selective visible radiation. After years of development, methods have been found to coat the interior of glass tubes with various phosphors to deliver visible light generated in them by the ultra-violet produced by electric discharges in gas-filled tubes.

The coming of the fluorescent light has tremendously widened the potential use of glass as a lighting fixture material and it is to be expected that the field will continue to expand.

The carbon arc and the incandescent lamp are both light sources of intense brightness. Efforts to reduce the brightness of the incandescent light by frosting or coating the glass bulb did not reduce the brightness sufficiently to effectively reduce glare. Some improvement in controlling this annoying glare was effected by the use of opal glass diffusing globes around the bulb. How-

ever, the surface brightness was still too high to eliminate the glare of the intense light source against a dimly lighted background, and indirect or semi-indirect lighting fixtures, including troffer lights and cove lights at or near the ceiling line within the walls, were used to throw the light principally upon the ceiling and from there, diffuse it to all parts of the room. Glare is entirely attributable to excessive brightness contrasts within the field of view.

Originally, it was thought that the surface brightness of the fluorescent tube would be low enough to be used without any intervening protection. However, it was soon found that these fluorescent tubes still offered too great contrast with the background to eliminate glare, and now nearly all lighting engineers agree that it is desirable to reduce the brightness of the tube by shielding with glass or other means to a value even below 1 candle per square inch. Accordingly, almost all fluorescent light installations require the use of glass, either flat or in some particular bent form to produce the lighting effects desired.

Fluorescent lights are several times more effi-



Lighting engineers and designers obtain handsome results with the co-operation of the Company engineers in commercial lighting.





These fixtures are similar to those on Page 5. Flat plates are used instead with satisfactory results.

cient than incandescent lamps of the same wattage and have gained wide acceptance in hotels, retail stores, office buildings and factories. The growth of the industry has been phenomenal and is expected to continue.

Scientific research and practical experience

prove that better lighting immediately improves the efficiency of personnel, conserving eyes and increasing overall productivity. More and more light, even up to 100 and 150 foot candles is being specified for general illumination, which means an increasing number of light sources. The quality

of the light becomes more and more important as quantity increases and this means an increasing use of glass shields to control quality. In offices, stores, and living quarters, glass shields of various kinds have been found almost indispensable. The use of these shields reduces the efficiency of the luminaires only slightly while greatly improving the distribution of the light and invariably improving the appearance.

To meet this anticipated requirement, the Pittsburgh Plate Glass Company has developed lighting glasses of special composition to meet specific needs, particularly for fluorescent lighting. These glasses are fabricated in several different patterns, designed to diffuse the light and reduce the surface brightness at the light source, to assist in uniformly illuminating areas within the range of view of the observer and eliminate glare, and add to decorative value of fixtures.

Pittsburgh special lighting glasses—reeded water white, rough water white, reeded opal, rough opal, rough flesh tinted, and special enameled glasses—are made in several thicknesses and may be bent into a great variety of shapes. To obtain decorative, light-correcting, and special dif-

fusing effects, light-transmitting ceramic enamels may be fired on the glass shield in full or partial coverage. These special lighting glasses are designed (1) to shield the tubes as efficiently and effectively as possible; (2) to transmit high percentages of light without undesired color distortion; (3) to diffuse or, in some cases, reflect light to points where it is most useful; (4) to correct or alter color effects of light sources, for example, flesh tinted glass to give warmth and softness to the color of 3500°K. white tubes for beauty parlors, restaurants, etc.

Pittsburgh Lighting Glasses are available in decorative patterns and with light-scattering surfaces to improve appearance and decrease annoying reflections. Opal glasses diffuse light much more than clear sandblasted glasses, and are more easily cleaned. Flesh tinted glass corrects the light from regular fluorescent tubes to a warmer, more pleasing value. Of course, the regular Pittsburgh Plate Glass Company products may also be used in fluorescent lighting fixtures.

The Pittsburgh Lighting Glasses are of the general category of the Carrara glasses and are opalized principally by fluorine.

SECTION "C"

PROCESSED PRODUCTS

C-1

BENT GLASS

C-2

HERCULITE TEMPERED GLASS

C-3

LAMINATED SAFETY GLASS

C-4

MIRRORS

C-5

CERAMIC ENAMELED GLASS

PROCESSED
PRODUCTS
C

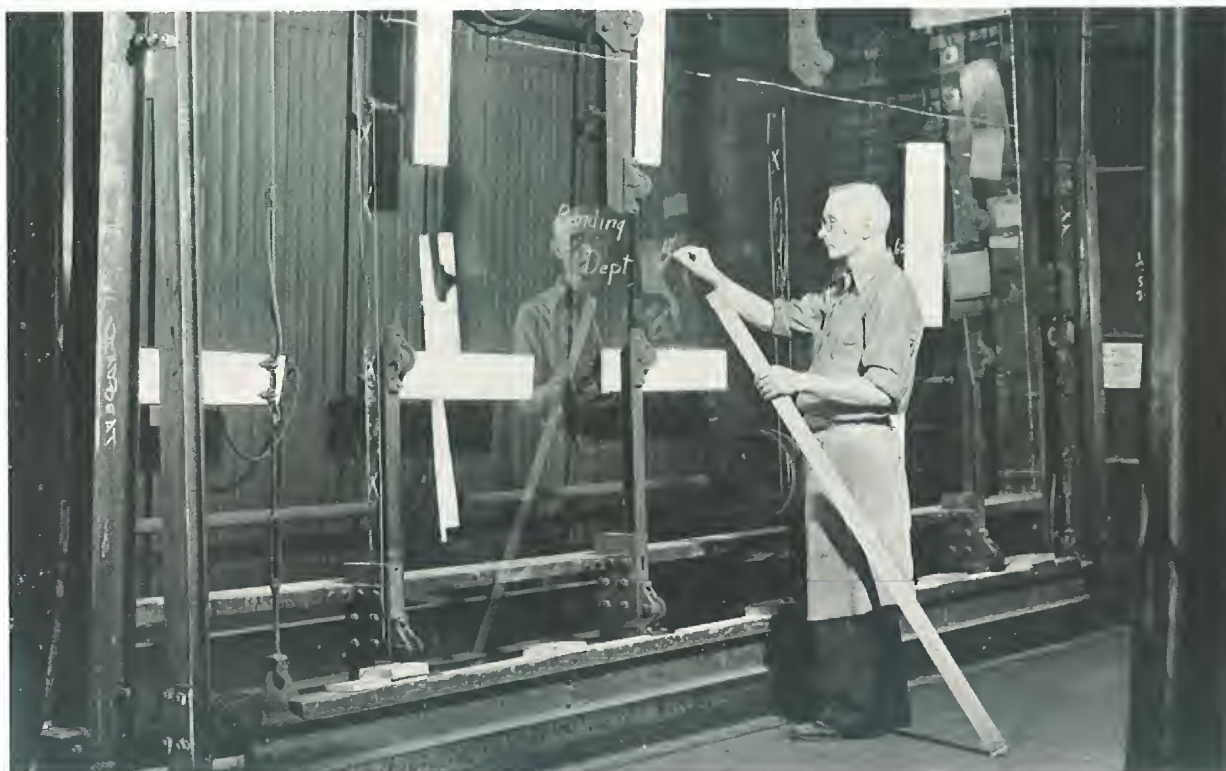
PROCESSED C
PRODUCTS

C-1

MAKING BENT GLASS

Bent Glass

Vases and bowls of formed glass had been in use for many years before flat glass became a product of general interest and distribution.



Marking up the glass suitable for bending is operation number one. It will be bent accurately to the required radius upon completion.

THESE PRODUCTS were built up by winding glass threads around clay or sand molds maintaining the glass hot enough so that each thread adhered to its neighbor or in some instances placing the whole formed mass into an oven and reheating to a point where each thread fused into its neighbor. The discovery of the method of forming glass by the use of a blowpipe upon which a gob of glass had been gathered, which could be blown into a hollow shape by the workman, in the course of years made obsolete the technique just de-

scribed and also made it possible to produce a more finished article.

Usually, these formed shapes had a somewhat restricted opening, particularly if the article was blown. More or less flat dishes, bowls, etc., were made either by the thread method or were cut from the lower half of some blown shape. True contours could not be obtained by either of these primitive methods nor could truly satisfactory surfaces be developed thereby.

With the advent of sheet glass the possibility of



A template of exact dimensions and contour is made for every bend and accurately develops a mold on the furnace floor. The craftsman sifts fine refractory material over the mold.

using flat glass to be bent to contour by the application of heat became evident. As a result, flat glass has for many years been bent into curved shapes for watch and clock face covers, picture covers, taxidermy cover glasses, decorative furnishings, and other similar novelties. Plate glass seldom was used because almost invariably the surfaces of the glass would be damaged in the process of bending.

A few shops devoted to glass bending as a specialty appeared in various strategic locations. The output was usually limited and the cost high. These shops customarily used one or another of two methods. The more general process was that which involved only the action of gravity upon a piece of flat glass resting on a metal mold of the desired shape or very frequently placed upon a mold made by hollowing out a depression in powdered clay which is commonly known to the trade as bending sand, and then softened by heat. The whole assembly, furnace, mold, and glass was

heated by gas or coal fires to a temperature high enough to permit the glass to sag under its own weight to meet the mold. The fires were then extinguished and the whole assembly cooled slowly to room temperature.

In other cases, the glass was placed upon a metal mold, the mold and glass then being heated to a point where the glass began to sag. The mold with the glass upon it was quickly removed from the heat and the glass pressed to contour by plunger press. Temperature control, except by visual observation, was entirely lacking. The surfaces of the glass were usually badly marked, and poorly reannealed. In most instances the finished bent glass was used with the convex surface towards the observer, as in show cases or show windows, and the resultant distortions and imperfections were thereby considerably minimized.

The development of polished plate glass brought with it also a demand for curved store window and show case glasses and other bends



The bending furnace receives the marked light for the mold. Placed exactly on the mold, the glass will follow the bend when the furnace reaches a determined temperature.



of large dimension. Because of the sizes involved, fabrication of these glasses by mechanical means was not possible and bending by gravity alone was the only available method. The size of these lights also ruled out the use of metal molds and made it imperative to use sand molds. This process is still used for the production of store window glass and other large dimension bends.

The development of temperature control instruments has made it possible to predetermine the temperatures to which a furnace shall be carried to have the glass bend very nearly to the desired contour. At a given temperature the glass will sag under its own weight only sufficiently to meet a definite radius of curvature.

About 1932 there arose a demand from the automobile industry for bent glass windshields, rear windows, etc. This demand required a perfection of surface and a freedom from distortion far beyond anything previously deemed necessary. Thereafter arose an exacting demand for glass for

military airplanes bent to shapes previously considered impossible and requiring a perfection of surface and freedom from distortion never before obtained—or approached.

Millions of curved plates were required for the automobile industry and new bending methods which would produce very large quantities of bent glass at much lower costs were developed.

The optical requirements for automobile glasses are very exacting and several methods of bending were found practical, using either solid molds or skeleton molds.

In these methods the glass is supported horizontally on molds, carefully cut or shaped to the exact contours required to have the glass fit the frame for which it is intended. The glass is then carefully heated until it bends down to nearly touch the mold everywhere around the edges and then quickly cooled to prevent further sagging, and annealed. Previous requirements for bent laminated safety glass had produced the tech-



Gently assisting the force of gravity with a long wooden pole, the operators check the progress of the bend. The furnace is allowed to cool and the completed piece is removed.



nique of bending 2 pieces of glass together on the same mold, either solid or skeleton. However, very few bent laminated glass windshields were made and all of those were long radius curves.

The development of tempered glass (described in Section C-2) presented a new product for glazing automobile doors and body windows. Principally, the bent automobile glasses are used in rear windows. They consist of a single piece of tempered glass usually bent to contour at the same time that it is being prepared for tempering.

Long radius bends, sections of cylinders or cones, are relatively simple to make. As the radius is diminished, temperatures must be increased and temperature control becomes more difficult. Spherical and spheroidal shapes frequently require several bending treatments to obtain satisfactory results.

The temperature to which the glass must be heated for bending depends upon the radius desired. Under its own weight, glass will bend to a

definite radius at a certain temperature. If a smaller radius is desired, the temperature must be increased. Gravity is the principal force used for practically all glass bending.

Where the gravitational pull is not sufficient to yield the desired bend, mechanical means may be used. Charred wood blocks, similar to the flattening blocks formerly used in the making of sheet window glass, may be manipulated by hand or levers and slides to push on the edges of the glass at the desired points.

When good optical surfaces are required, it is never permissible that any solid material shall touch any portion of the surface of the glass. All pushing and manipulating must be done on those portions of the plate which are afterwards to be cut off and discarded.

The type of mold used for bending glass depends upon the shape of the curve desired and the optical properties required. Some bends can be made on molds which do not touch the surface



A few of the more complicated bends that the military planes required in the last war. The Company efficiently produced a steady stream of these shapes.

of the glass, and therefore possess the best optical properties. Other bends require molds that contact the entire glass surface and the surfaces of these bent shapes are always somewhat damaged, depending upon the radius of curvature and the temperature required. Deep spheroidal shapes or shapes having large change in radius or in direction of bend require special bending techniques. The method is expensive and optical properties are never good.

Bends of more than approximately 90° of arc, which are to be laminated, require special processing, and cylindrical or conical bends processed accordingly, usually present little difficulty in laminating. It has never been found practical to laminate spheroidal shapes of more than 90° of

are, i.e., quarter circle. In all cases, when bending glass to be laminated, the several layers of glass must be bent at the same time on the same mold. Bent laminated glass is always produced by laminating 2 bent glasses together. It is not possible to bend the completely finished laminated safety glass as a unit.

Where bent tempered glass (Section C-2, Tempered Glass) is required, if the curves are straight element bends, the glass may be bent at the same time that it is being heated for tempering. For more complex bends, the bending must be accomplished first, the glass annealed, and subsequently subjected to the tempering process.

All kinds of glass can be bent—including window glass, plate, and Carrara Glass.

C-2

MAKING HERCULITE GLASS

*Herculite Tempered Plate Glass

For many years the fragile nature of glass has been generally recognized. Its susceptibility to breakage has induced a reluctance to handle large plates of glass because they might break, and in so doing, might entail injury. The sharp points and keen edges of glass fragments offered a hazard which most people sought to avoid.



Plate glass enters the tempering furnace to become Herculite.

*Herculite is the trade-mark of Pittsburgh Plate Glass Company for tempered glass.



Spiralling gracefully, this stairway is further distinguished by its Herculite balustrade.

THE FLEXIBLE heat-control of electric furnaces made possible the development of a glass item far surpassing any previous similar product in its resistance to breakage and almost complete elimination of the hazard of personal injury as a result of breakage.

As long ago as 1914, in World War I, many German battleships were equipped with tempered glass portlights. Relatively, these portlights were very small in superficial area. They were made by pouring molten glass into a cold metal mold and immediately placing a cold metal plate on top. The glass was afterwards ground and polished and was very highly tempered although some of the temper was removed in the grinding and polishing process.

About 1930 the art of electric furnace construction had developed to a stage where very

much larger pieces of glass could be uniformly heated and the heated plate quenched between steel plates. Gradually the development of methods for chilling or quenching the glass in streams of air made it possible to heat-treat larger and larger areas until now it is possible to satisfactorily temper glass plates to the maximum dimensions of 72 inches high by 108 inches long.

The process of tempering glass is similar to that used in tempering steel. In both cases the material is heated to a relatively high temperature and then quenched or cooled rapidly. To temper a glass plate, it is first heated uniformly until it begins to soften. At this point, the whole mass of glass has been expanded. The plate is now quickly moved to a position between 2 air chests from which air is blown against the glass uniformly over the entire surface with equal pressure on both sides. This almost instantly chills and solidifies the surfaces in the expanded condition, while the inner portion of the plate remains relatively hot for some time after the surfaces become solid. The interior portion tends to contract as it cools; while the fixed outer surfaces cannot contract. The interaction of these forces results in placing the surfaces under high compression while the interior of the plate is placed in high tension.

Essentially, glass never breaks under compression. When an ordinary piece of glass or other material is bent, the convex surface is placed in tension and the concave surface is placed under compression. Consequently, breakage always begins on the convex or tension side. If a piece of tempered glass is bent, the same phenomena as just described occur. However, in this instance, the convex surface is initially in a state of compression which must be overcome before any tension can be set up, and then before breakage can occur, the same tension stress must be developed as would be necessary to break an untempered plate. As a result, tempered glass, while no more rigid than ordinary annealed glass, is many times stronger and may be bent and twisted at least 5 times as far without breaking.

When a piece of material is heated on one side alone, stresses are set up in the material of exactly the same character as though it were being bent or deflected mechanically. The heat-resistance properties of tempered glass are described in Section J, Technical Data.

After glass is tempered it cannot be cut, drilled or sawed. Any deep break in the surface will



Distinctive doorway for a distinguished building. Herculite adds scale to this impressive entrance. The doors are $\frac{3}{4}$ inch thick.

release the compressive strain and the entire plate will crumble into small cubical fragments resembling rock salt. The size of the particles depends upon the thickness of the plate and the degree of temper. The small size of these fragments minimizes the danger of serious injury.

The compression surfaces extend well into the

glass and scratches or abrasions of the surface will not cause breakage unless they completely penetrate the highly compressed surface.

The tempering process is subject to exacting precautions. The temperature must be held within a few degrees one way or another of the optimum. The glass must be heated and cooled uniformly



He sees what is going on in this modern tank handling a reaction that is better processed in Herculite glass.

at every point on the surface, both sides, and each light must be tempered individually.

In tempering, the plates must be supported so that there is no danger of bending or sagging. (See Section C-1 Bent Glass.) Flat glass sheets are always supported in a vertical position for tempering. If preformed bent glasses, sections of cylinders, or cones are to be tempered, they are supported with the straight-line elements of the section vertical. Three-dimensional curves or sections of spheroids must be supported horizontally if they are not to lose their contours in the process. Bent tempered glass sections may be prepared by bending the glass and immediately quenching. For these products, skeleton molds, pressure molds, or special cribs in which the glass is supported between small wires which are held by spring tension in the curved shapes

desired may be used. Three dimensional or spheroidal bends may be simultaneously heated for bending and tempering.

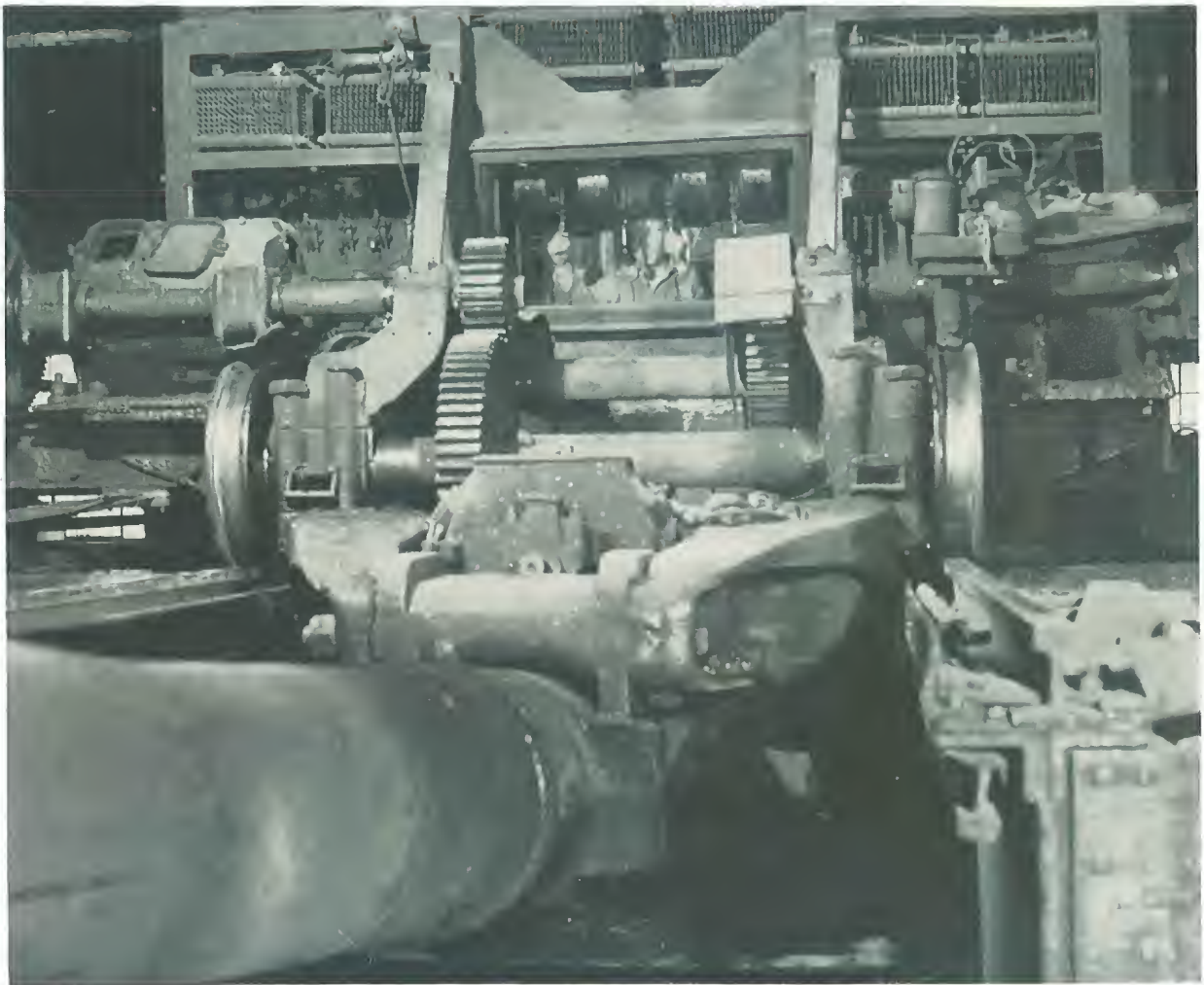
In the quenching process, the distance of the nozzles or air jets from the glass surfaces has a marked effect upon the air pressure reaching the glass. The rate of cooling determines the amount of strain introduced into the finished tempered plate. In general, the air pressure required is lower for heavy glass and higher for thinner glass. For this reason, it is impractical to fully temper very thin glass since the very high air pressure required will distort the fragile thin glass.

In deep curved shapes or very thin glass, the difficulties in developing satisfactory all-over, immediate air pressures for fully tempered glass render this production almost impossible. Accordingly, tempered glass is produced in several different degrees of temper, based upon fundamental strain specifications. In general, glass which is $\frac{1}{4}$ inch thick or more can be tempered fully or, to any other less degree, while glass which is less than $\frac{1}{4}$ inch thick can be tempered only in smaller dimensions and lower degrees of temper. Three dimensional or spheroidal shapes, even though the thickness may be greater than $\frac{1}{4}$ inch, cannot be fully tempered by known techniques.

The use of tempered glass either by itself or in laminated form (described in Section C-3) has presented many new problems in tempering technique. In airplane glazing, the weight of the product is a most important consideration and of necessity thin glass is therefore used. As we have just stated, this glass cannot be fully tempered. Many of the panels required are also curves of extreme depth to accommodate various streamlining air-foil requirements and again, full tempering becomes essentially impossible. These glasses have an intermediate temper which may be determined with considerable exactness in any given instance.

The lamination by laminated safety glass methods of 2 pieces of tempered glass with a comparatively thick sheet of plastic between the glasses, and extending beyond the edges of the glass, results in a very strong assembly known as Flexscal which is fully described under Section C-3, Laminated Safety Glass.

There are several requirements for the satisfactory conduct of the tempering operation which have direct bearing upon the ultimate utilization of the tempered glass. All of these limitations are fully described and illustrated in Section F.



Herculite protects the workman in the cab of this open-hearth charging machine. He is better able to spot his charge from this improved position. It takes him right up to the furnace door.

Rectangular plates which are $\frac{1}{4}$ inch thick or less, with no dimension greater than 24 inches, and without curved edges or rounded corners may be tempered without edgework, provided the edges are clean and free from flares, spalls, or chips. The edges of all other thicknesses or dimensions of glass must be polished, satin finished, or seamed. The seaming should be at least $\frac{1}{2}$ inch wide and at an angle of 45° with the surface of the glass.

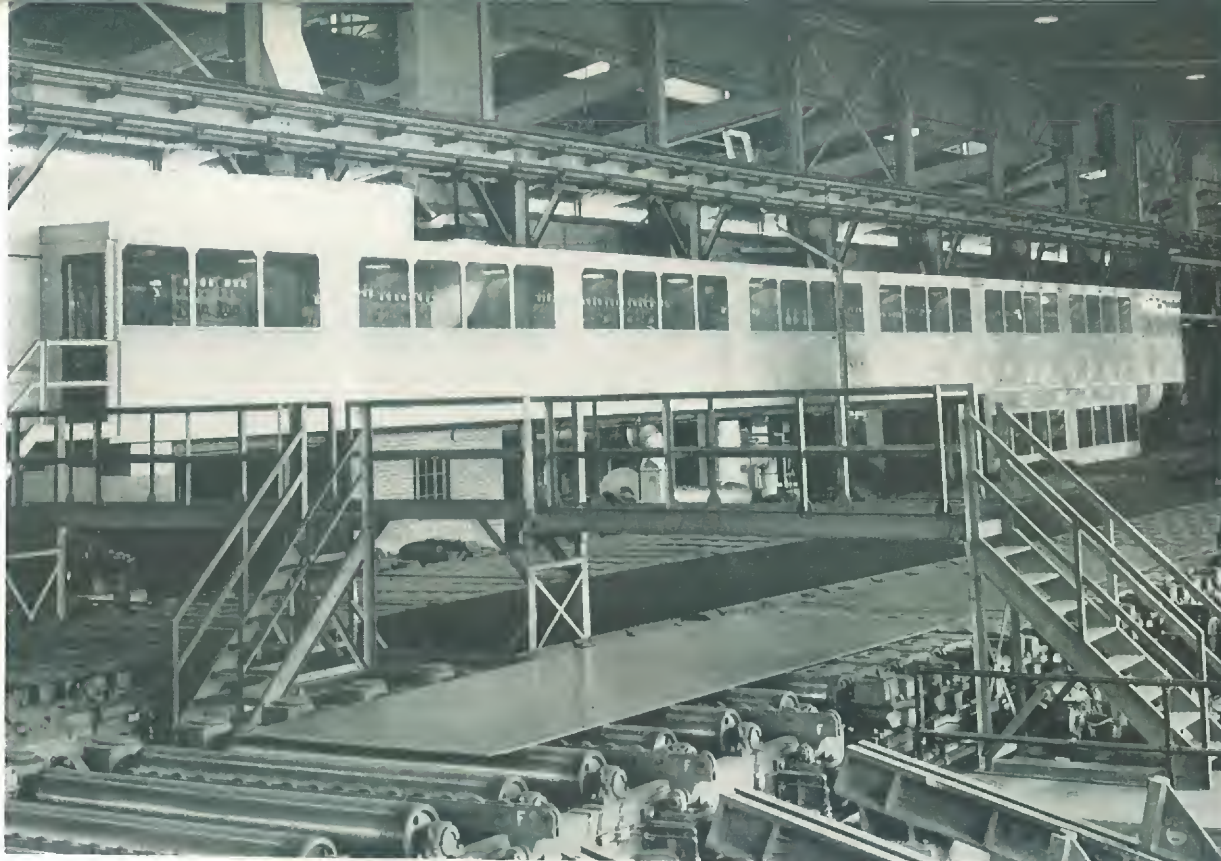
Rough, serrated, or deckle edges cannot be satisfactorily tempered. Flares or feather edges on the glass must be ground away until the edge is perpendicular with the faces of the glass before seaming is done.

Pursuant to the preceding paragraph, the edges of all glass thicker than $\frac{1}{4}$ inch should be flat ground and seamed before tempering.

From all standpoints, no fabrication whatso-

ever should be attempted upon the glass after it has been tempered. The toughened condition of a piece of Herculite is due to its balanced, but strong opposing forces. Whenever these forces are unbalanced by beveling, grinding, design cutting, or otherwise, plates so treated may break during processing or subsequently, as a result of a relatively light bump or jar, or even without apparent assignable cause.

In general, the glass to be tempered is suspended by stellite-tipped tong points in a miniature reproduction of the well-known ice tongs. The stellite points are pressed into the cold glass and thereafter the glass should not be moved in the tongs. Very small plates, especially of thicker glass, can be successfully tempered by supporting vertically and resting on the bottom edge. In general, however, the only satisfactory way to



A jam on this rolling table whips the steel fragments about dangerously. The operators, protected by Herculite glazing, occupy a protected preferred position above the machine.

temper flat plates of glass is to support by hanging in tongs. It is usually possible to so locate these tongs that the resultant tong marks shall be on an edge suitable to the uses intended.

In general, the depth of bend which can be tempered must not exceed 4 inches from any chord of the bend to the deepest point of the outside surface.

It is much more difficult to temper only one plate of a kind successfully than it is to carry through a large run of the same kind, where a definite production cycle may be established.

The established rules governing the prefabrication of glass to be tempered are given in Section F and must be adhered to strictly.

It is usually entirely possible to identify a piece of tempered glass provided the necessary equipment is available. In almost all cases, tong marks may be found somewhere along one edge. On very small pieces these tong marks may be almost invisible, while on large heavy pieces they will usually be easily seen. If one views a piece of tempered glass so that the light from a clear sky impinges on the glass and is reflected from

the glass at angles of approximately 57° , there may appear characteristic patterns developed by the light polarized in this manner. If one looks through a piece of tempered glass at the surface of a more or less quiescent body of water at various angles, this same characteristic pattern may sometimes be observed, particularly if a piece of Polaroid is held between the eye and the glass, as an analyzer. Usually the pattern will appear more or less iridescent. If a piece of Polaroid is placed on one side of a piece of tempered glass with light shining through the combination so that it enters the Polaroid first and then comes through the glass and is finally observed with another piece of Polaroid, crossed with the first piece, the pattern will be quite distinct and iridescent. Although the pattern is here called "characteristic," this term is not intended to mean that the pattern is easily apparent or uniform from one plate to another. The so-called design, as viewed by any of the methods just described, is by no means a measure of the degree of temper, which can be determined only by special laboratory technique.

C-3

MAKING LAMINATED SAFETY GLASS

Laminated Safety Glass

During World War I the first use of poisoned gas in warfare was a very effective weapon due to the fact that the forces upon which gas was first used were quite unprepared and unprotected against it.



A 30-caliber rifle bullet punctures a $\frac{3}{8}$ -inch steel plate. A square of $1\frac{1}{2}$ inch Multiplate Bullet-resisting glass stops the same missile.

OBVIOUSLY, one of the chief needs was for a gas mask which would protect its wearer against the inhalation of deadly fumes. Such a mask presupposed the use of eye-protective means as an integral part of its makeup, and glass discs or other shapes were immediately used.

However, the repercussion of gunfire and flying fragments of bullets or even of stones or pebbles thrown up from the ground caused the simple glass lens to break and splinter. This at

once rendered the mask useless in excluding gas and imperiled the eyes of the wearer.

Some time previous to the war, a French chemist one day inadvertently dropped a bottle which had contained a solution of cellulose nitrate from which the solvent had entirely evaporated. Dr. Benedietus observed that although the glass of the bottle was thoroughly broken, nevertheless, it hung together and more or less retained its original contours, the glass

fragments being still adhered to the cellulose nitrate film and held in place thereby.

There had been several automobile accidents in Paris in which persons had been seriously injured by flying glass from the windshields and at once the possibilities of using some combination of cellulose nitrate and glass to render the glass nonscatterable became evident to Dr. Benedictus.

Although the discovery just described occurred in France in 1903, the first patent on laminated safety glass was granted in 1905 to Woods in England, and Benedictus obtained a patent in 1910. Nevertheless, it was not until the outbreak of war in 1914 made necessary safety glass lenses for gas masks that Dr. Benedictus' discovery bore fruit. The assembly of small pieces of glass with a pyroxylin film between pairs was relatively simple and afforded to military personnel a positively needed protection. Consequently, laminated safety glass lenses were the first outstanding quantity production of safety glass products.

It is only a step from a 2 inch diameter laminated safety glass disc to a windshield in an automobile or other such assemblies. Nevertheless, such developments present a characteristic slow-motion picture, and laminated safety glass is no exception. It was necessary to develop economical methods for permanently adhering the plastic to the glass, and in order that costs might be low, it was also necessary to develop methods for adhering prepared sheets of plastic to the glass rather than to produce the films directly on the glass. Breakage of glass in process was excessive and costs correspondingly high.

By 1924 the techniques which had been developed seemed to warrant attempts at mass production of laminated safety plate glass for automobile windshields to meet a positive demand from individual automobile owners. In 1927 Pittsburgh Plate Glass Company and E. I. duPont de Nemours jointly organized a company to produce laminated safety glass. A few years later this company became the Duplate Division of Pittsburgh Plate Glass Company, upon transfer of the Dupont interests.

This original production was carried out by assembling together sandwiches of 2 pieces of glass with cellulose nitrate between. A number of these assemblies were piled alternately with thick sheets of soft-textured paper and the pile set between the jaws of a heavy steam-heated platen press. The press was closed, the temperature raised, and the pressure increased until glass



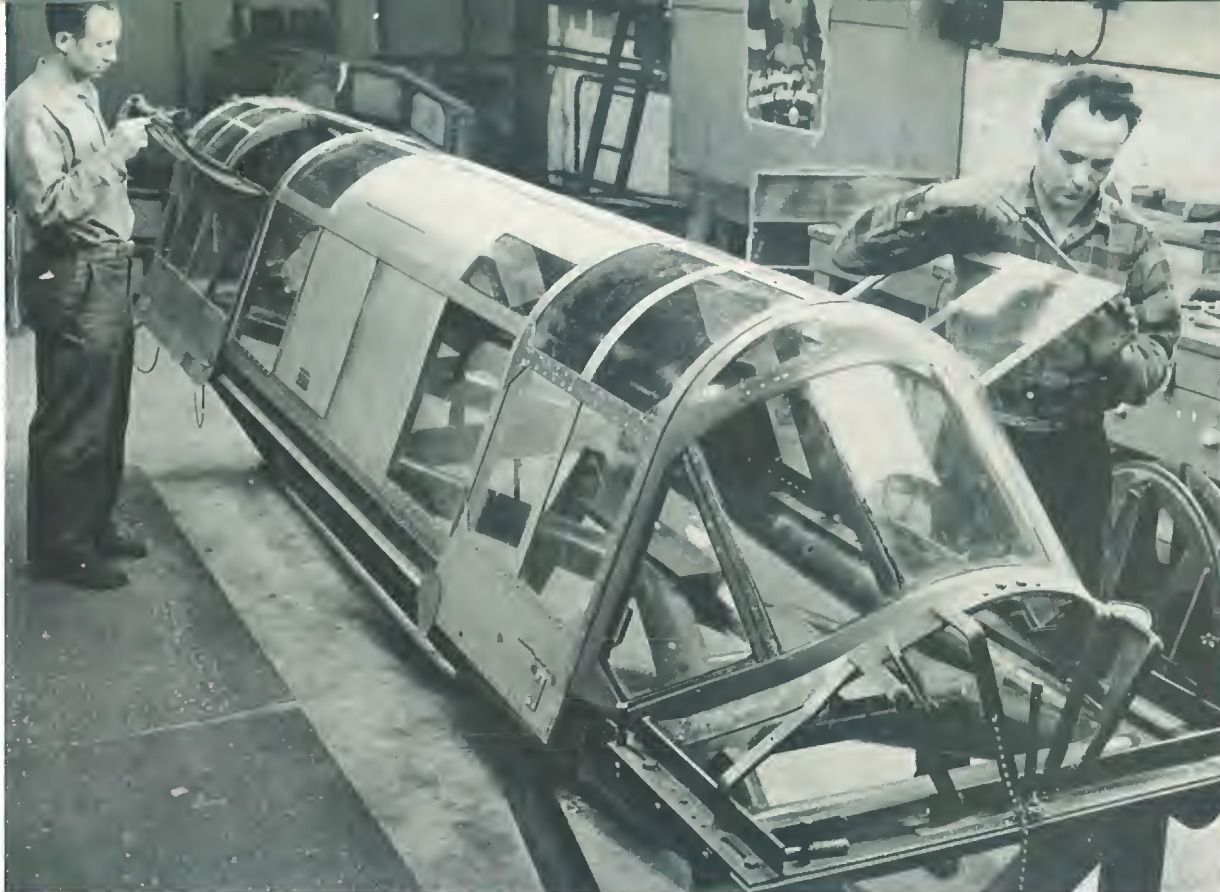
Piles of plastic cut to contour preparatory to quantity production of safety glass.

and plastic were well adhered. Production was still slow and the product costly.

The search for better methods and better materials was continuous and about 1928 Pittsburgh Plate Glass Company engineers developed the Creighton autoclave process which is today generally in use throughout the industry. A production line was developed simultaneously although this assembly line has undergone a number of changes and improvements through the years.

Both cellulose nitrate and cellulose acetate, which was also used, were found to have some unsatisfactory characteristics and the search for other more suitable plastics was unremitting. Ultimately the vinyl synthetic resins were investigated and Hi-Test Safety Glass was developed.

In present practice, plasticized polyvinyl butyral or one of its related products is most widely used as the interlayer in Hi-Test Laminated Safety Glass. The plastic is supplied as sheeting in large rolls. It is quite soft and flexible. It may be elongated some 250 per cent and will recover to within 1 per cent of its original dimensions. Since there is a strong tendency for adjacent sheets of plastic to adhere to each other, the plastic sheeting is thoroughly dusted with bicarbonate of soda before being made up into rolls.



The glass armored canopy of a scout bomber is assembled on a jig. Both bent and flat plates are used to produce an aerodynamically sound shape.

The glass is cut to the exact contours required. Special cutting machines have been developed for the mass production of standard shapes. Other shapes are cut by hand. The coated plastic sheet is cut to the same contours as the glass to which it is to be assembled, and here again there have been devised machines for cutting volume requirements while smaller quantities are cut by hand with sharp knives guided by templates. The plastic is very carefully conditioned in special equipment so that it shall contain exactly the right amounts of moisture. The glass is transported from the cutting room to the head of the assembly line where it is passed through scrubbers and is thoroughly washed and dried. The plastic is similarly treated and passes finally between metal rolls to discharge any static electricity which may have developed.

The pairs of glasses are carried side by side on a continuous roller conveyor into a thoroughly air-conditioned dust-free assembly room. Here the girl operators place an appropriate sheet of plastic upon one of the glasses and fold the other over upon the first, making sure that the edges of the glass and the plastic are in exact alignment and that there are no inclusions of dust or other particles between glass and plastic.

The assembled glasses and plastic pass from the assembly room through an electrically-heated chamber or area in which the temperature of glass and plastic is raised sufficiently so that upon passing through a pair of rubber-coated pinching rolls, the glass and plastic may be thoroughly adhered about the edges and more or less thoroughly throughout the area of the plate.

At the end of the conveyor, the assemblies are stacked on edge upon carriages designed to exactly fit the autoclave cylinders. When the carriage is loaded, it is moved to the autoclave for final lamination under hydrostatic pressure.

The autoclave consists of an immense steel cylinder which may be filled with a fluid. It is equipped with a substantial cover which may be locked in place. The carriage loaded with glass is set into the autoclave and the top secured. Fluid is pumped into the cylinder through a heat exchanger and the temperature built up to 260°F. and allowed to drop to 160°F. while the pressure is held between 150 and 200 pounds per square inch. The glasses remain in the autoclave approximately 25 minutes.

Thence, they move through a scrub room, where the fluid from the autoclave is thoroughly washed off, to the edgers. Here the edges are finished to



The special bombardiers window, specially ground, of laminated plate glass is the triangular insert in the flying fortress' nose.

the desired contours. Mechanical edgers have been devised for volume production and the rough-cut glasses are set into one end of the machine and emerge finished. Individual glass or small numbers of the same pattern are edged by hand operators on metal or abrasive wheels. Polishing of the edges is accomplished by buffing.

The finished glasses are again placed upon a conveyor belt and pass to the examiners. Each glass is very carefully inspected by operatives who look through them and at them under mercury vapor lamps—first against a dark background and then against a white background. Any defects are marked and that glass is re-examined before being finally rejected or passed. Each light is stamped with a label showing the size and the inspector's number and, in the case of stock automobile glasses, showing the Auto Glass Parts number, and the glasses are ready for packing.

The same procedure is followed in the packing room as has already been described for plate glass.

The processes and procedures just described apply equally well to laminated safety plate glass, "Duplate"; to laminated safety sheet glass, "Aerolite" and "Duolite"; "Multiplate" Bullet-Resisting Glass; and other flat laminated prod-

ucts. Bent laminated safety glass, very large sizes or very thick laminations, cannot be assembled on the production line, but must be assembled by hand. After a short preliminary pressing in the autoclave with the glasses protected from penetration of the autoclave fluid by rubber bags from which the air has been exhausted, the glasses are removed from the bags and final pressing accomplished as with flat glass. The bag process just described, is used throughout for the lamination of Flexseal.

Duplate is laminated safety plate glass. It consists of 2 pieces of plate glass with an interlayer of plastic. In Hi-Test Duplate, the interlayer is polyvinyl butyral. Originally, Duplate was intended primarily for use in motor vehicle windshields and many of the states require that laminated safety plate glass shall be used in the windshields of automobiles as specified in American Standards Association Safety Code Z26.1-1938, Glass, Flat for Glazing Motor Vehicles Operating on the Land Highways, with which Duplate entirely complies.

In addition to the use in automobile windshields, Duplate has found many other applications. It is used throughout in the glazing of doors and windows of higher priced or deluxe model automobiles and in many other applications where undistorted clear vision with safety is required.

Duplate is available in all thicknesses from $\frac{1}{4}$ inch up to and including $2\frac{1}{2}$ inches, although it is very seldom supplied in thicknesses materially exceeding $\frac{1}{2}$ inch. Where thicknesses greater than $\frac{1}{2}$ inch are required, it is customary and more practical to use Multiplate.

Aerolite, Laminated Safety Sheet Glass is especially designed for use in airplane fuselage windows, but has many other applications as well. It consists of 2 sheets of very thin Pennvernon Sheet Glass—photo glass—with a plastic interlayer. Polyvinyl butyral is used in Hi-Test Aerolite. Aerolite is available only in $\frac{1}{8}$ inch thickness. It weighs approximately 1.62 pounds per square foot.

Duolite Laminated Safety Window Glass, made up of two sheets of Pennvernon Window Glass with a plastic interlayer—polyvinyl butyral in Hi-Test Duolite—is manufactured in 3 thicknesses; $\frac{7}{32}$ inch full, in which the glass used is single strength (S.S.) Pennvernon Window Glass; $\frac{1}{2}$ inch full in which double strength (D.S.) Pennvernon is used; and $1\frac{15}{64}$ inch full (known as Duolite Combination) in which one glass is S.S.



No! The young lady did not sit behind the armored windshield when the gun was fired! This is a test sample.

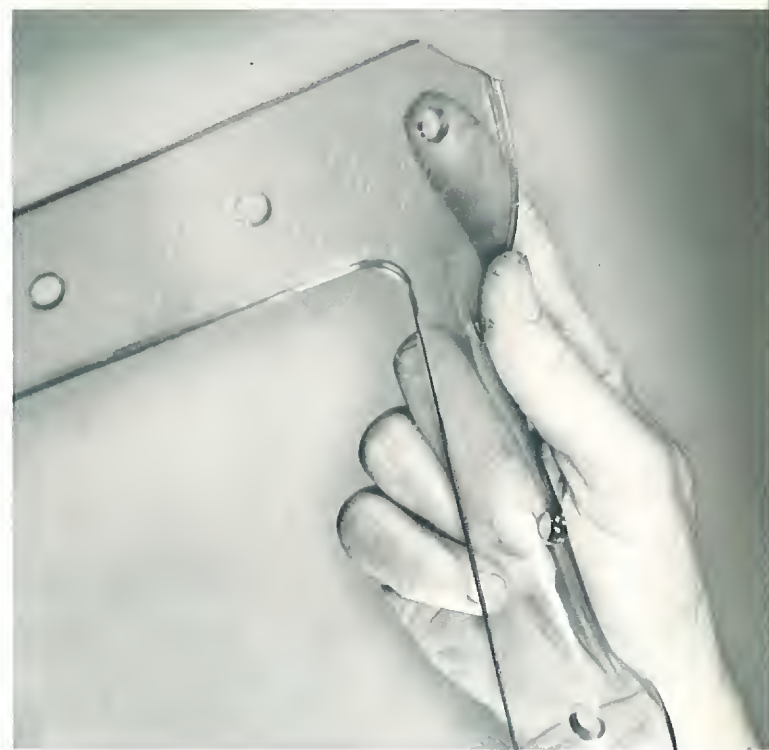


An ambidextrous cutter head turns the jig corner slickly to produce the glass parts.

Pennvernon and the other is D.S. Pennvernon.

Aerolite and Duolite comply with all of the requirements of American Standards Association Safety Code Z26.1-1938, except for the requirement of undistorted vision. Duolite is widely used in the body lights of all types of motor vehicles and in other applications where the requirements are not sufficiently stringent to demand the use of Duplate, or where the perfect vision and beauty of Duplate must be sacrificed in favor of lower production cost.

Multiplate Bullet-Resisting Glass consists of a number of layers of polished plate glass of the same or varying thickness interleaved with sheets of plastic. It is available in all thicknesses from $\frac{1}{2}$ inch up, although it is infrequently used in thicknesses less than $1\frac{1}{2}$ inches or greater than 3 inches. The $1\frac{1}{2}$ inch thickness will effectively stop a .45 caliber pistol bullet fired at it at point blank range, while a 5 inch thickness will effectively stop .50 caliber armor piercing military ammunition at 50 yards range. Thicknesses greater than 5 inches have been assembled but have not been considered practical, particularly because of the extreme weight. The greatest thickness which has been used on U. S. military airplanes is 3 inches. The 3 thicknesses most in demand are called



Flexseal provides a flexible mounting tab around the perimeter of military plane glazing.

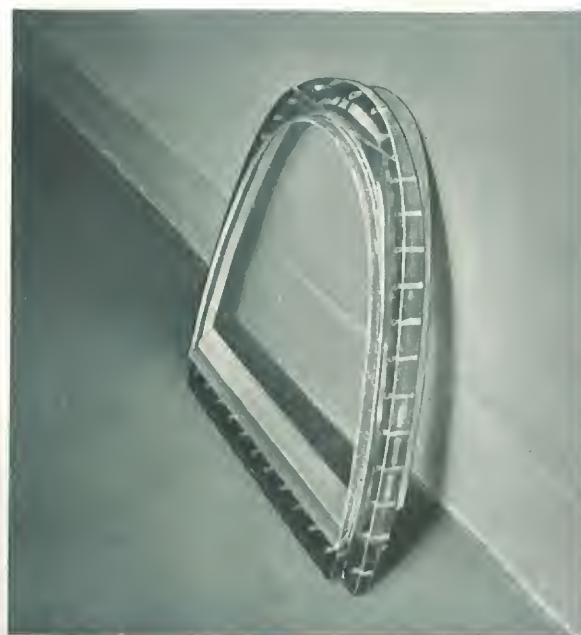


The autoclave is a new tool in industry to apply pressure and heat for sealing glass to plastic.

Super-Multiplate, averaging about $1\frac{1}{16}$ inch thick, Hi-Resist Multiplate, averaging about $1\frac{1}{16}$ inch thick and Hi-Power Multiplate, 2 to 3 inches thick.

Multiplate Bullet-Resisting Glass has found very wide use in the equipment of banks, armored cars, and a number of other places where protection against banditry or against possible small arms fire is desired.

Flexseal has been developed especially to resist breakage under the heavy air pressures and frame distortions experienced particularly in the operations of military aviation. It consists usually of the lamination of two pieces of semi-tempered plate glass with a thick interlayer of polyvinyl butyral which extends beyond the edges of the glass. This extended edge of plastic may be made flush with the faces of the plate or may be undercut to any desired degree on either or both sides of the plate. It is frequently undercut on the outside surface so that the glass may be glazed into an airplane fuselage flush with the face of the plane.



The windshield for a combat plane is the heaviest carried aboard the ship.

The assembly is set into the frame so that all of the pressure of the setting is taken by the plastic. It may be held in place either by clamping alone or by passing bolts through the plastic edge. It should be remembered that the plastic has great extensibility and when lights are assembled into a frame as just described, the glass area tends to act as a piston, essentially without deflection while the pressure is taken up by the plastic. In some instances, the pressures developed are sufficient to tear the unreinforced plastic out of the setting even though bolts have been used to hold it in place. Difficulties of this character led to the development of metallic reinforcement of the plastic edge. In this product a piece of metal is assembled within the plastic edge and extended just to the edge of the glass or approximately $\frac{1}{4}$ inch between the glasses. It is possible to obtain this construction in bent shapes as well as in the flat product. Semi-tempered glass is usually used in the production of Flexseal. It is also possible to use either ordinary annealed glass or fully tempered glass in the assembly.

Flexseal, with or without the metal insert, is a custom-made product, designed with many variations to meet many specific problems.

All laminated safety glass products may be supplied with holes, notches, or other similar fabrication. Multiplate is frequently supplied with gun ports or speaking holes, etc.

LABELS THAT IDENTIFY LAMINATED SAFETY GLASS

MULTIPLATE



X

PITTSBURGH
PLATE GLASS COMPANY

DUPLATE



PART NO.

PITTSBURGH
PLATE GLASS COMPANY

DUOLITE
COMBINATION



PART NO.

PITTSBURGH
PLATE GLASS COMPANY

AEROLITE



PART NO.

PITTSBURGH
PLATE GLASS COMPANY

GLASS BULLET RESISTANT

SPEC. AXS-1406 5 JAN. 1945
PART No. B 285382



PITTSBURGH
PLATE GLASS COMPANY
THIS SIDE OUT

C-4

MIRRORS

Mirrors

A still body of water forms a surprisingly good reflecting surface and any human drinking from a spring must be aware of the phenomena of reflection. Reflected images formed the basis of many legends and some of our present-day superstitions are undoubtedly based upon prehistoric ideas.



This smart living room boasts a wall mirror, mantel mirror, valances, and mirror wall inserts for a charming effect.

THOUSANDS of years must have elapsed between the time of the first discovery or recognition of reflection as a physical phenomenon before the art of beating gold and silver was sufficiently advanced for their makers to use these metals as reflecting surfaces. Even the most highly polished metal cannot present a reflected image materially more accurate than that seen in the surface of a pond and many such metal mirrors must have been distinctly less satisfactory than a bowl of water. During the period of the Roman Empire the development of metal mirrors was quite far advanced.

Some mirrors must have been made from granite, obsidian, etc., by polishing their surfaces to a degree beyond that possible in polished metals.

The knowledge of the making of glass dates back into almost prehistoric time. The development of glass sufficiently clear to serve as a mirror was not encompassed before the Eleventh Century A.D. Glass was used as a base upon which sheets of metal were applied to afford better reflecting surfaces.

Venice was the center of medieval glassmaking and by the same token was the center of fine mirror production.

Early mirrors, made by applying a thin sheet of metallic tin and mercury amalgam to the back surface of the glass, produced reasonably satisfactory reflections. This method of manufacture was common only a few years ago and even today people speak of the "mercury on the back of the mirror," as of old.

About 1865 a French chemist made mirrors by chemically depositing pure metallic silver upon glass surfaces. This discovery is the foundation of nearly all commercial mirror manufacture, although the original solutions have been considerably modified and improved.

Entirely new methods for producing reflecting films on glass surfaces have been developed within the last decade and while not yet available as mass production methods, they have enabled the use of other metals besides silver and gold as the actual reflecting surface. Only a few years ago it was felt that the ultimate in mirror manufacture had been attained, but today new techniques have opened the way for tremendous future developments in the uses of mirrors.

During "The Gay Nineties" and for many years thereafter, no architect of note would have thought of recommending anything other than a

French Plate mirror, nor would a person of consequence have owned any other. France was pre-eminent in plate glass manufacture and also, therefore, in mirror manufacture. Today American plate glass and American mirrors are the finest ever produced anywhere.

In Section B-1, the manufacture of plate glass and the methods of grading are described and the reader will remember the references to silvering quality and mirror glazing quality. These 2 qualities present the highest finish and the clearest metal and are used in mirror manufacture because the silvered surface tends to accentuate the least defect.

Relatively limited areas of any plate of glass may be of satisfactory quality for use in mirrors. This necessary careful selection accounts to a considerable degree for the cost of a fine plate glass mirror.

Mirrors are used in many different ways, for many purposes. Some are highly decorated by various surface treatments of the glass; some are used as plain beveled mirrors without frames; and some are used as plain flat glass mirrors in frames. All surface treatments of the glass are completed before the mirror is silvered. Throughout any of this processing, the glass must be handled with extreme care and good housekeeping is a pre-eminent qualification of a successful mirror shop.

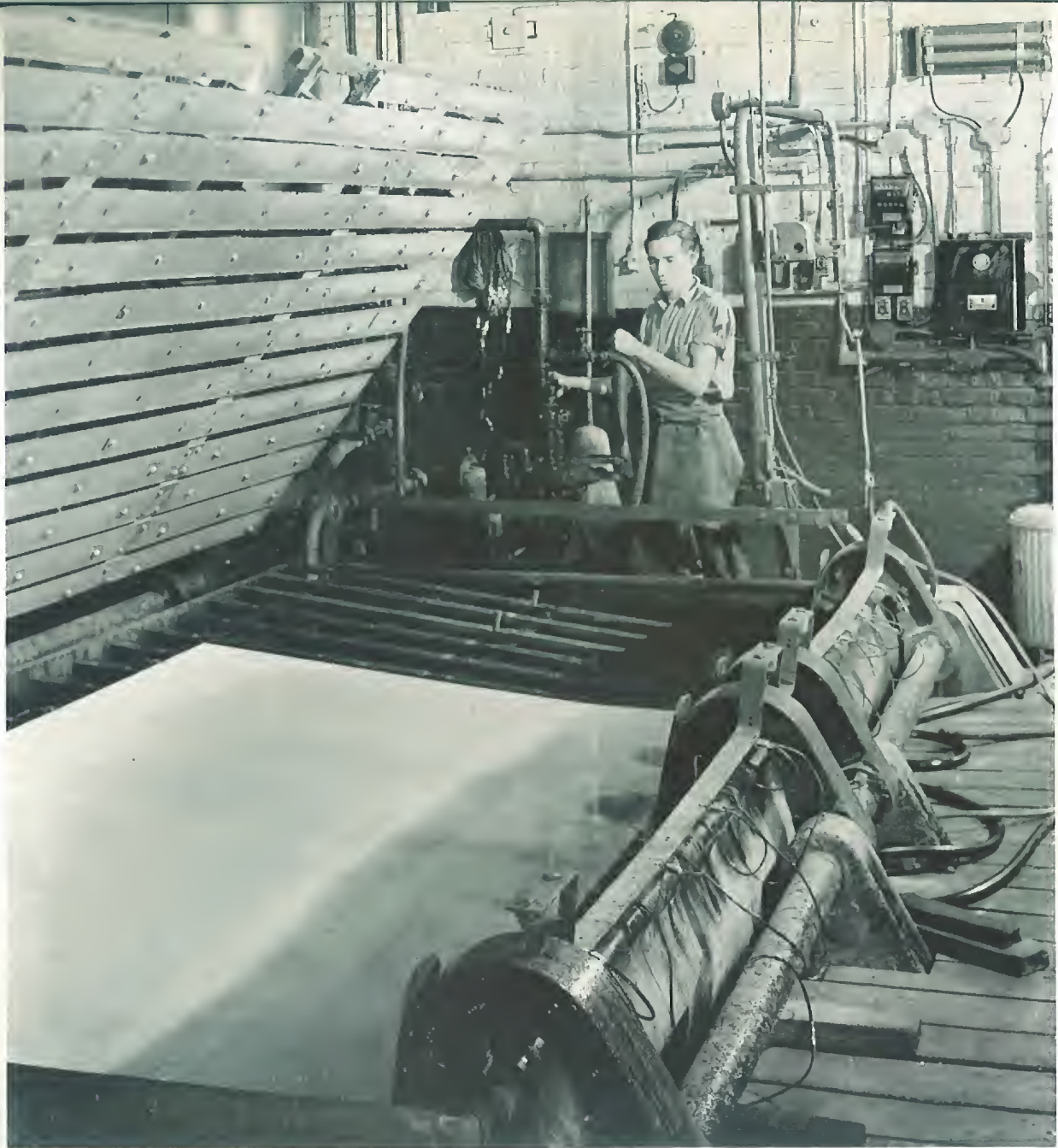
No glass can be satisfactorily silvered unless it is scrubbed chemically clean. The glass must be thoroughly scrubbed with distilled water and thereafter no foreign matter is allowed to contact the cleaned surface. The silvering process is a chemical process and a small drop of perspiration, a small speck of dust, or even a gas contaminated atmosphere may ruin what would otherwise be a satisfactory product.

The actual making of the mirror is accomplished in a room which is kept as nearly dust-free as air conditioning can make it.

In present-day practice, the silvering table may be a continuously moving conveyor belt or the steam-heated, felt-covered, heavy table exclusively used until a few years ago.

Although there are several different commercial techniques for the production of mirrors, the so-called hot precipitation method prevails.

In any of the methods, essentially the same silver solution is used. This solution is prepared by dissolving chemically pure silver nitrate in chemically pure distilled water. To this solution, ammonia is added. This precipitates silver



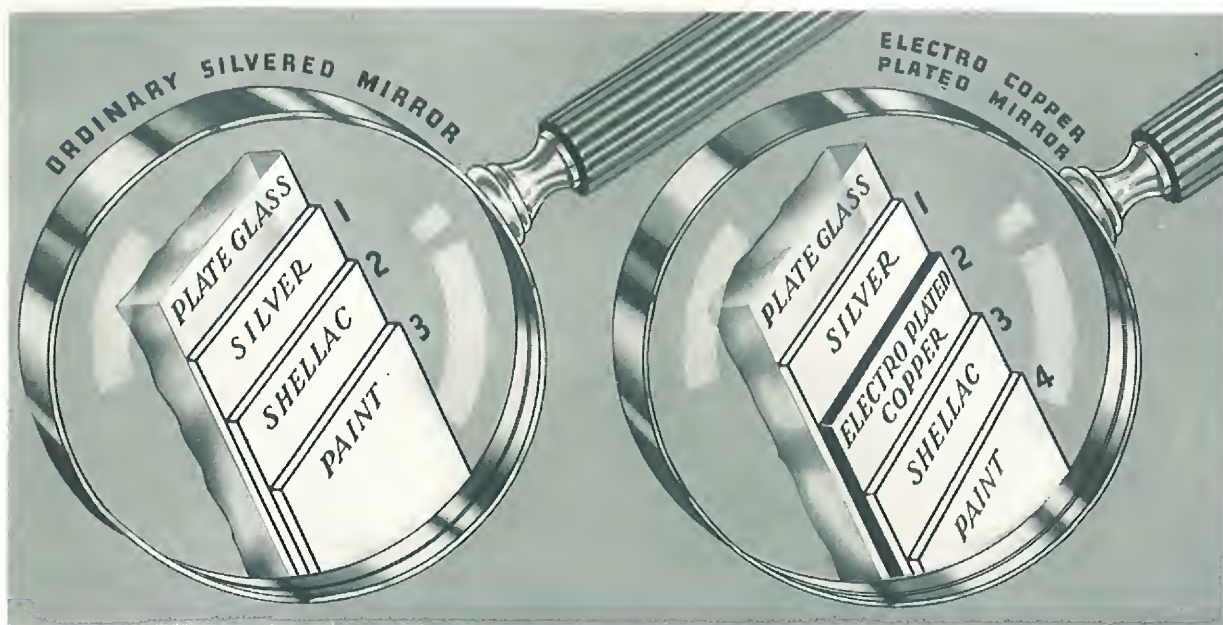
This sheet of plate glass has received its coating of electrolytically deposited copper. It will now be further protected by shellac and paint applications.

hydroxide in suspension in the solution and ammonia is further added until the precipitate is entirely dissolved and the solution again becomes clear. In order that metallic silver may be deposited from the silver ammonia solution upon the prepared glass surface, some chemical reducing agent must be used. This reducing agent may be any one of several different materials. More generally, a solution of rochelle salts or tartaric acid is used.

In commercial mirror production the solutions of silver and reducing agent are mixed and imme-

diately but slowly poured upon the prepared surface of the glass, lying on a steam-heated table at a temperature of 100°F. or slightly over. Later, infra-red radiation has been used as a source of heat and the time necessary for deposition of the silver is thereby decidedly diminished. The time required for proper and complete deposition of the silver is from 15 minutes to 1 hour, depending upon the temperature and strength of solution.

More recently, there has come into use a process for the silvering of mirrors at ordinary room temperature or less. This is known as the cold



The extra operations involved in making the copper-backed mirror return to the owner a greater measure of value in long life and lasting high quality.

process and excellent mirrors are produced after only 5 to 15 minutes at room temperatures. Usual practice is to keep the temperature of silvering room and solutions slightly below 70°F.

In some mirror shops, mirrors are made on a continuous production basis. The glass is carried on a conveyor under spraying equipment from which the silvering solution is sprayed upon the glass. The solutions vary in composition and usually contain a powerful reducing agent which quickly precipitates the silver. The silver solution and reducing agent are usually brought together at the nozzle and atomized with compressed air at the instant of applying to the glass. This method may be used on stationary plates, as well as on a conveyor system. Silvering may be completed in from 30 seconds to 1 minute.

At the present time, probably 99 per cent of all commercial mirrors are made by one or another of the processes just described for depositing pure metallic silver on glass. Various color effects may be obtained by silvering different glass products. Principally, these colored mirrors are used for decorative purposes.

Gold mirrors are produced by depositing pure metallic gold from solution by the action of reducing agents in a manner analogous to the silvering methods just described. The solutions are very sensitive and quite difficult to handle. Extreme care must be used in pouring, as the least splatter

of the solutions affects the depth and color of the film. Gold films are always so thin that it is quite possible to see through the film, before the mirror backing has been applied.

A large portion of automotive rear-view mirrors are of a type known to the trade as Galena Blue mirrors. These are also produced by methods similar to the silvering processes, although the reflecting film consists of lead sulphide (PbS). The reflection value of this type of mirror is approximately 25 per cent while for silver and gold mirrors it will approximate 80 per cent. Lead sulphide mirrors are also frequently used for decorative purposes, especially where subdued lighting effects are desired.

Within the last 10 or 15 years much attention has been given to the development of evaporated metallic films. In the early stages of development, these mirrors were more a scientific curiosity than a commercial product, but they were found most useful in a number of optical instrument applications and particularly in the smaller astronomical telescopes and cinematograph production studios. The film principally used is an alloy of aluminum and magnesium which has a high reflection value, particularly in the ultra-violet region of the solar spectrum. It is this fact which makes the aluminum magnesium film particularly valuable in astronomy, since silver films and other metallic films absorb nearly



The mirror installation in a luxurious home reflects the exquisite decoration to delight the owner with a double helping.

all ultra-violet. Many astronomical measurements and discoveries depend upon the range of stellar spectra which can be analyzed photographically. The great 200 inch reflector in the Mt. Palomar Ob-

servatory in California will ultimately be coated with an evaporated aluminum magnesium film.

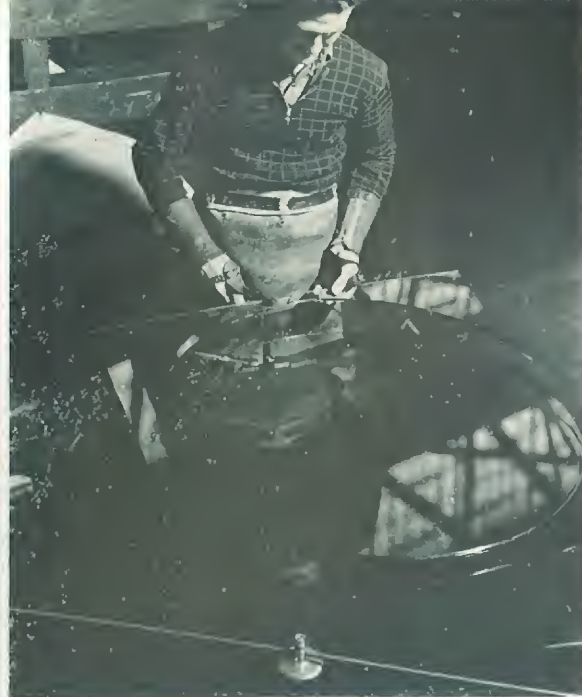
These films are produced by the condensation of volatilized metal upon glass surfaces, in a



A buffet table in the modern mode. Here are improved plate glass and sandblasted striping to achieve a sophisticated ensemble.

vacuum chamber. The glass must be scrupulously chemically clean and as free from any absorbed gases or moisture as may be practicable. The glass is placed in a vacuum chamber which is equipped with special electric heating elements. The metal

to be evaporated is placed in proper relation to these heaters and the chamber sealed. A very high vacuum is developed within the chamber by means of special diffusion pumps and when the required vacuum has been maintained for a short



A classic mode is reflected to increase the pleasure to the eye. Right, a circular mirror is cut from a square sheet with a circular scribe.

time, the electricity is turned on. The metal is brought to the boiling point almost instantly and the vaporized metal condenses upon the cold glass surface. The film may be made to almost any desired thickness by controlling the amount of metal available for volatilization and the time the current is allowed to flow.

These mirrors are especially suitable for use as front surface or first surface mirrors, as the aluminum magnesium alloy is highly resistant to tarnish, and the hardness and chemical resistance of the film seem to improve with age. They are gradually entering the commercial field to an increasing extent, limited principally by high costs and the small sizes currently available.

The protection of the reflecting film on commercial mirrors has long been a matter of concern to mirror manufacturers. The silver film, if unprotected, may be readily scratched and marred, and atmospheric conditions may have a very detrimental effect upon the permanence of the film. It is therefore essential that the protection backing be good, if the mirror is to last.

The standard backing used by almost all mirror manufacturers of high-grade plate glass mirrors consists of a coat of shellac or its equivalent, covered by a coat of special mirror backing paint. It is customary to use only a single coat of mirror backing paint on window glass or so-called shock mirrors, omitting the shellac coat.

The finest, most permanent mirrors are the Copper-Backed mirrors. These are made with a double silver coating upon which a film of copper

is electrolytically deposited, and the whole protected with the standard mirror backing. The permanence of Copper-Backed mirrors insures a life several times that of the usual commercial mirror.

Many mirrors are made to specification which usually means that they must pass certain specified tests. A large number of accelerated laboratory tests have been made and compared with prolonged roof-exposure and other similar tests. As a result, the accelerated tests have finally been narrowed down to the Salt Spray Test which gives a maximum of information in a minimum of time.

In the Salt Spray Test, the mirrors are set at an angle of about 45° , with the mirror back up, and kept constantly wet with an atomized solution of common salt. The ordinary mirror should remain unaffected at the end of 96 hours, while the Copper-Backed mirrors must withstand the test for 300 hours or more.

Virtually all of the mirrors produced in the United States meet the requirements of Commercial Standard for Mirrors, CS-27-36, as issued by the U. S. Department of Commerce, Standards Division, in co-operation with a majority of the mirror producers. The provisions of this standard will be found in Section J-6. Commercial Standard CS-27-36 considers the production of regular clear mirrors, basically, but does not cover transparent mirrors nor front surface or first surface mirrors, nor evaporated films.

Transparent mirrors may be made by any of the processes which have been described. How-



A band of architectural glass is added to this mirror mantel to create an all-glass fireplace of smart distinction.

ever, the thickness of the reflecting film may be so exactly controlled that it will transmit any desired percentage of light. The strength of the silvering solutions used, and the time-temperature ratio, determine the thickness of the film. These mirrors are variously known as transparent mirrors, X-ray mirrors, speakeasy mirrors, beam splitters and one-way vision mirrors.

These transparent films, however made, are extremely delicate and easily damaged by handling. As a result, transparent mirrors must be protected, if they are to be at all permanent. Protection of the metallic film sometimes consists only of a coat of shellac or transparent lacquer, which is applied as nearly uniformly as possible. More usually, a second piece of glass is placed over the lacquer film, and the edges bound with tape. The transparent mirrors even when thus protected are by no means as permanent as ordinary mirrors.

Front surface or first surface mirrors are just what the name implies. Ordinary mirrors are actually second surface mirrors, because the light must first pass through the glass to reach the reflecting film, while in front surface or first

surface mirrors, the glass acts only as a support for the film, and the light falls directly upon the reflecting surface. The brilliance and accuracy of the metallic reflecting surface depends upon the polish and accuracy of the foundation surface, and the care with which the reflecting film is prepared. Silver films tend to tarnish rapidly and are frequently protected by a very thin lacquer coating. In astronomical mirrors, this lacquer coating is especially undesirable and the mirrors must be resilvered frequently.

The aluminum magnesium vaporized film is almost immune to tarnish. An exceedingly thin film of aluminum oxide forms on the surface of the metal immediately upon exposure to the air, and protects the reflecting film from deterioration. This oxide film is highly transparent and its thickness is less than a wave length of light. Consequently, it has little or no detrimental effect on the accuracy of reflections from the metal surface.

Any type of glass can be silvered. Mirrors in which ordinary sheet glass or window glass is used are never as satisfactory as polished plate glass mirrors.

Special decorative effects may be produced



This label is now well known to the public as a symbol of sound value and integrity. It is affixed to every plate glass mirror.

by coating the colored glasses with silver, gold or lead sulphide, and each combination produces a distinctly different result. Characteristic reflection curves for each of these combinations are shown in Section J-6.

Mirrors may be re-silvered if desired. However, it is never practical to attempt to restore the surfaces which have become marred or scratched through cleaning, and unless this fact is thoroughly understood, the re-silvered mirror may prove seriously disappointing.

Re-silvering is accomplished by removing the old silver, thoroughly cleaning the glass without re-polishing, and then applying the new silver by the same process as in making the original mirror. This work is done at the customer's risk of breakage, both in transportation and fabrication.

ONE-WAY VISION GLASS

Up to the present moment, no one has devel-

oped any material through which light may pass in only one direction. Nevertheless, many people seem to desire such a product and it may be that in some future day it will be available, although all present knowledge would seem to indicate the contrary.

Everything which we see is observed by reflected light, unless we are looking directly at a light source itself. If we wish to read papers under a glass desk top, the light must, of necessity, pass through the glass to the object and be reflected from the object back through the glass to our eyes. A one-way transmitting glass would preclude this possibility.

However, by special composition of the glass or treatment of the glass surfaces, it is possible to produce the effect of being able to see through a glass in a given setting, in only one direction. This effect is secured by a difference in light intensity on opposite sides of the glass. The fact remains, however, that there is no known means



Double-faced mirrored louvres add a crystal palace touch to this lovely boudoir. A sample of the imagination of the progressive decorator.

by which any glass or other transparent material may be made actually nontransparent when viewed from one side, while being transparent when viewed from the opposite side, except by this difference in illumination. If so-called "one-way vision glass" is set into an opening between a highly illuminated room and a darker room, irrespective of how the glass is set, a person stand-

ing in the darker room will always be able to see what transpires in the more highly illuminated room, while the person standing in the darker room cannot be seen by the person in the highly illuminated room.

Nevertheless, the property of transmitting light in one direction only is frequently attributed to transparent mirrors, and to certain very deeply



A boudoir table that uses glass lavishly. The side panels covering the shelves are sandblasted designs. Mirrors and plate glass team up to do a beautiful job.

colored glass, either in neutral tint or some specific color. These materials are merely partially transparent. They transmit so little light that reflections from objects on the darker side of the glass are not sufficiently intense to again penetrate the glass and produce a sensible image on the retina of the eye. Glasses which are suitable for one-way transmitting purposes usually transmit be-

tween 5 per cent and 10 per cent of normally incident white light. A specification covering a special glass used by the United States Post Office Department for secret observation windows requires that this glass shall meet the above specification and further shall transmit not less than 1 per cent nor more than 10 per cent of any specific wave length of light in the visible spectrum.



Pretty figurines and objets d'art are double in quantity and beauty above a glass desk with mirror drawers. The map is of sandblasted black Carrara.

This type of product has certain very definite and quite satisfactory applications, but among them are not included the windows of bathrooms or bungalow bedrooms. If the windows of a house

are glazed with so-called one-way vision glass, it is entirely possible during daylight for the person within the house to see what transpires out of doors, while the person out of doors will not

be able to see into the house at all. However, after dark the conditions are reversed, and when the lights within the house are turned on, it becomes possible for the person out of doors to see clearly into the house, while the person within cannot see objects outside. This same phenomenon may be observed to a greater or lesser degree in normally glazed windows, and window screens and lace curtains tend to increase the effect—to this extent, any transparent glass may be called a one-way vision glass. No possible alteration of the glass or its position can affect these results.

Let us repeat again that there is not actually any such thing as a one-way transmitting glass. Any such effect depends absolutely and solely upon differences in light intensity on opposite sides of the glass.

SPECIAL FILMS

Low Reflectance Films

Several years ago, the Glass Industry was electrified by the announcement that Dr. Katherine Blodgett, working in the laboratories of the General Electric Company at Schenectady, had produced films on glass which rendered the surfaces of the glass essentially nonreflecting. She first floated stearic acid or soap on the surface of water, in films of molecular thickness, and then by repeated immersions of a piece of glass slowly through the soapy film, developed films of stearic acid on the glass. As the thickness of the film became greater, the reflectance from the glass surface diminished until the reflection virtually disappeared when the film had a thickness of $\frac{1}{4}$ wave length of light. The films thus produced were not sufficiently stable for commercial purposes and for some years remained merely chemical-optical curiosities. However, they did definitely stimulate research in that field and much work has since been carried on.

A few years later, perhaps stimulated by the development of evaporated metallic films, a research group at Massachusetts Institute of Technology announced the production of reflection reducing films by evaporating metallic fluorides upon the glass. These films are much more permanent than the stearate films, but still remain unsatisfactory for use on large glass sizes. They have proven eminently satisfactory for coating elements

of optical instruments to increase their range, whether by night or day.

None of these films will completely eliminate all reflection. They are specific for some given wave length of light and the reflectance increases as the light delivered to the surface varies in wave length from the norm. This produces some color effect which depends on the relative intensity of the reflected light.

The film must be nearly $\frac{1}{4}$ wave length in thickness and its index of refraction must approach the square root of the index of the glass.

The art of making these films has developed in the last few years as larger and larger vacuum chambers and better pumps have become available. The size of glass which can be coated successfully has increased to 24 inches by 24 inches. However, the films are still quite fragile.

During this same period, the investigation of chemical processes for developing low reflection films has been making progress and several different methods show definite promise of becoming commercially available. At least 3 such processes and possibly several others are being intensively studied and several of them have been used in military applications. It seems entirely probable that these films will have wide application in television developments, and in numerous other ways.

High Reflectance Films

Coincident with the study of high reflectance opaque metallic films which we call mirrors, and the low reflectance films just described, there has arisen an ever increasing interest in high reflectance transparent films. These films are analogous, but of opposite sign to the transparent low reflectance films. In this instance also, the film must be very nearly $\frac{1}{4}$ wave length in thickness, but the refractive index must be materially greater than that of the glass.

It seems probable that as the art progresses, these films may find many uses.

Both low reflectance films and high reflectance films may also be produced in multiple layers, each bearing its proper relation to the other. When so produced, the film thickness and index requirement for single films no longer apply, and as yet no definition of relationship between them has been established.

C-5

CERAMIC ENAMELED GLASS

Ceramic Enameled Glass

Ceramic Enameled Glass is made only in the enameling department at Works No. 4, at Ford City, Pennsylvania. A thin uniform coating of powdered ceramic enamel in a suitable liquid vehicle is spread over one surface of a plate of glass and fused into the plate at approximately 1150° F. It is available in a variety of colors, which may be opaque or translucent to varying degrees.



A well-known red horse identifies a dealer's outlet for a famous company.

IT may be procured in any standard plate glass thickness and in sizes up to 48 inches by 84 inches. The method of manufacture, similar to the tempering process, materially increases the strength and toughness of the plate, as well as the thermal endurance and working temperature. The shock resistance is many times greater than that of the clear annealed glass.

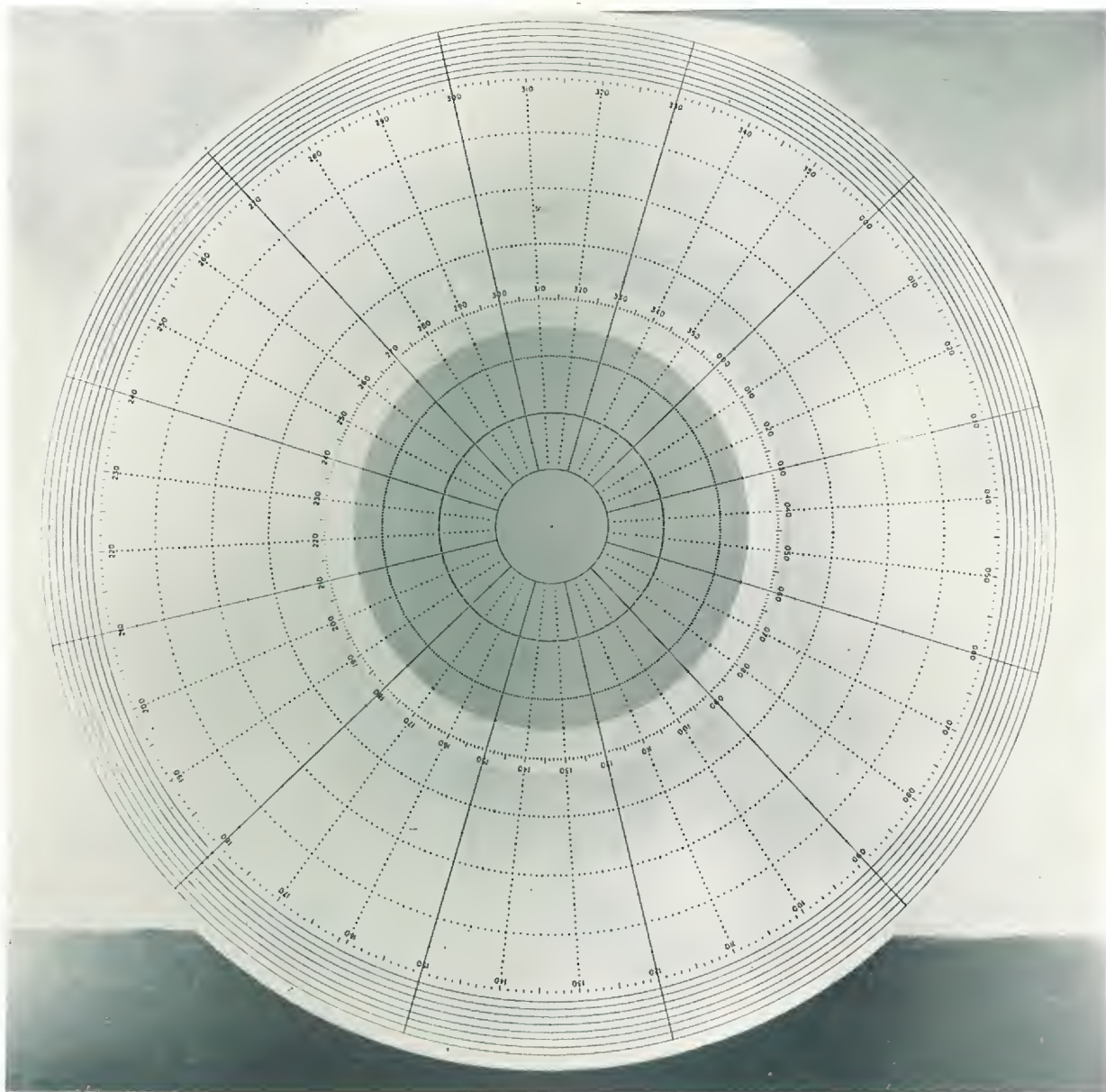
The enamels used are carefully fitted to the base glass, so that they shall not craze or chip. They are acid and weather resistant and the colors are permanent.

Special designs may be printed on the glass in

different colors by the silk screen or other printing processes, and then fired, for special purposes.

Enameled glass projection screens especially designed for back surface projection may be made in essentially any density desired, down to almost complete opacity—and may vary from point to point on the plate as required.

The enameling process is adaptable to lighting glasses and offers a most effective means of individual decoration. Almost any of the regular flat glass products, plain or with rolled patterns may thus be made available with a cleanable, light diffusing surface.

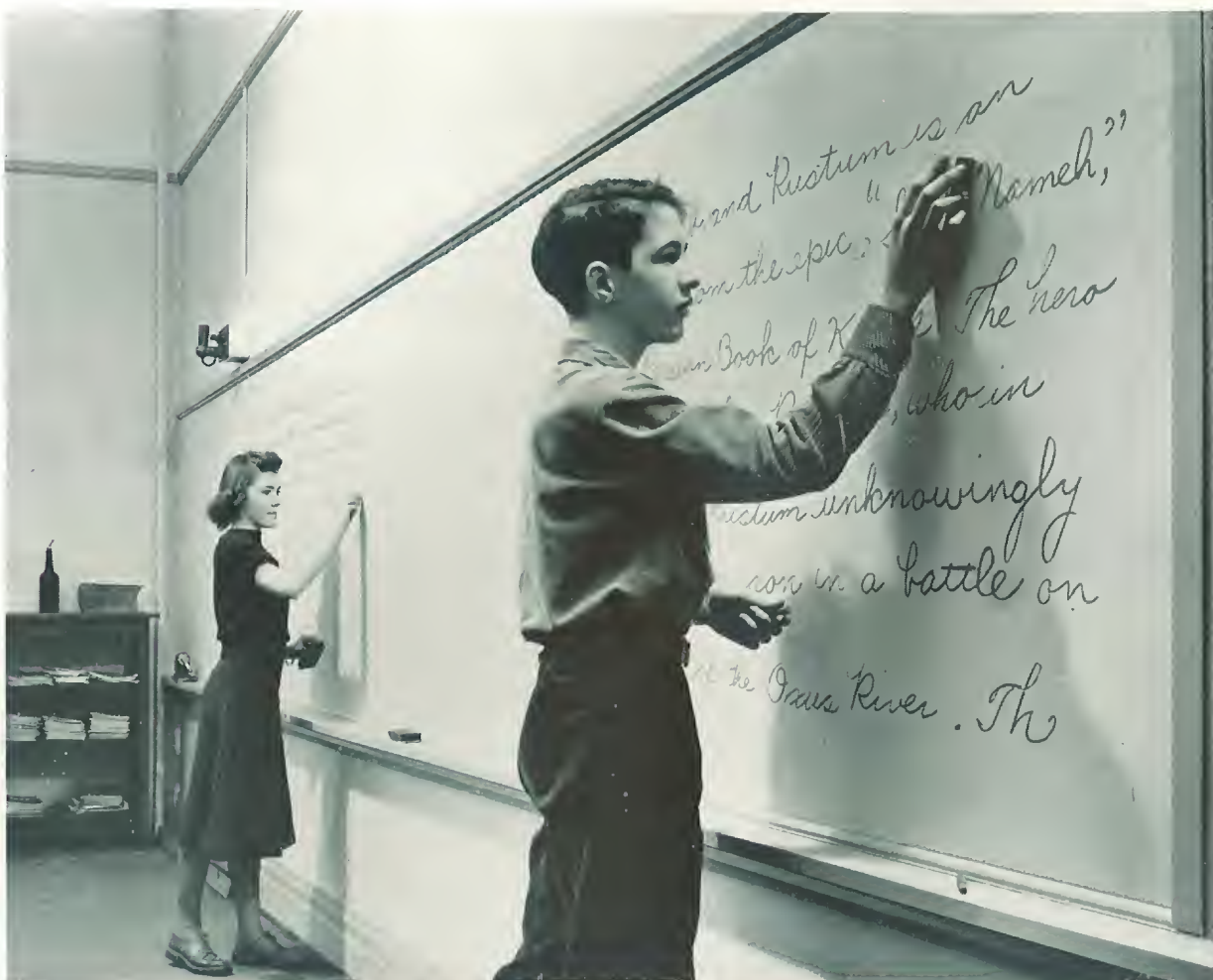


Radar from which there is no hiding uses a glass screen because glass will do that job better than any other material.

The ceramic enameled glass products played a considerable and important role in World War II. They contributed to the surpassing efficiency of the radar and radio equipment of our Navy, played their part in the work of aircraft carriers and the briefing of pilots, and assisted in the directing of torpedoes from our submarine fleet.

NUCITE GLASS CHALKBOARD

Nucite glass chalkboard is a specialized, standard ceramic enameled glass product which was introduced in 1939. It enhances the possibilities of working out the color and lighting schemes of architect, designer or decorator, while at the same



A blackboard becomes a white board. This is as it should be, but it has taken a long time to come about.

time it lessens eyestrain by avoiding the glare so noticeable on ordinary chalkboards.

Nucite is made just as any other ceramic enameled product except that the enamel is impregnated with an abrasive material. It is produced in 3 standard colors—green, ivory and black. The standard thickness is $\frac{1}{4}$ inch. Dark chalks are used on the ivory color, thereby more nearly matching the customary black on white of the printed page. Light chalks are used on the green and black. Green and black Nucite are essentially opaque. Ivory is translucent, and a light source placed back of the chalkboard affords a luminescent background for any inscriptions on the board.

The writing surface of Nucite is unexcelled. It takes chalk easily and smoothly. Chalk will not skip or chatter on the Nucite surface and erasures may be effected with a minimum of effort.

Nucite is nonabsorbent, and may be washed as often as desired. The surface will not become slick and shiny and readability will not suffer with extensive use of the boards. The impervious quality of the Nucite surface eliminates the unpleasant odors developed by accumulations of chalk-binder in the surface pores of ordinary chalkboards. The nonglare properties of a Nucite chalkboard surface are not altered by years of use.

Ivory Nucite makes an excellent projection screen for pictorial education purposes and affords the possibility of annotating a picture without detrimental effects on subsequent projections. The standard Nucite surface is too dense for satisfactory use as a back projection screen. Other ceramic enameled glasses have been especially developed for this purpose.

Nucite chalkboards are fabricated to required



A bulletin board of Nucite blends with the wall of this assembly room.

size at the factory. No cutting or drilling in the field is possible.

Nucite chalkboard installations for schools and educational institutions are handled by New York Silica Book Slate Company, which is equipped to furnish the specialized service involved and the many accessories that accompany these installa-

tions, such as: chalk-rails, map hooks, cork bulletin panels, etc.

Sales of Nucite chalkboards for commercial purposes, brokerage houses, bulletin boards, panels for rumpus rooms and children's playrooms either as chalkboards or permanent projection screens are handled through Company branches.

SECTION "D"

PREFABRICATED UNITS

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CARRARA GLASS PREFABRICATED UNITS

PREFABRICATED
UNITS

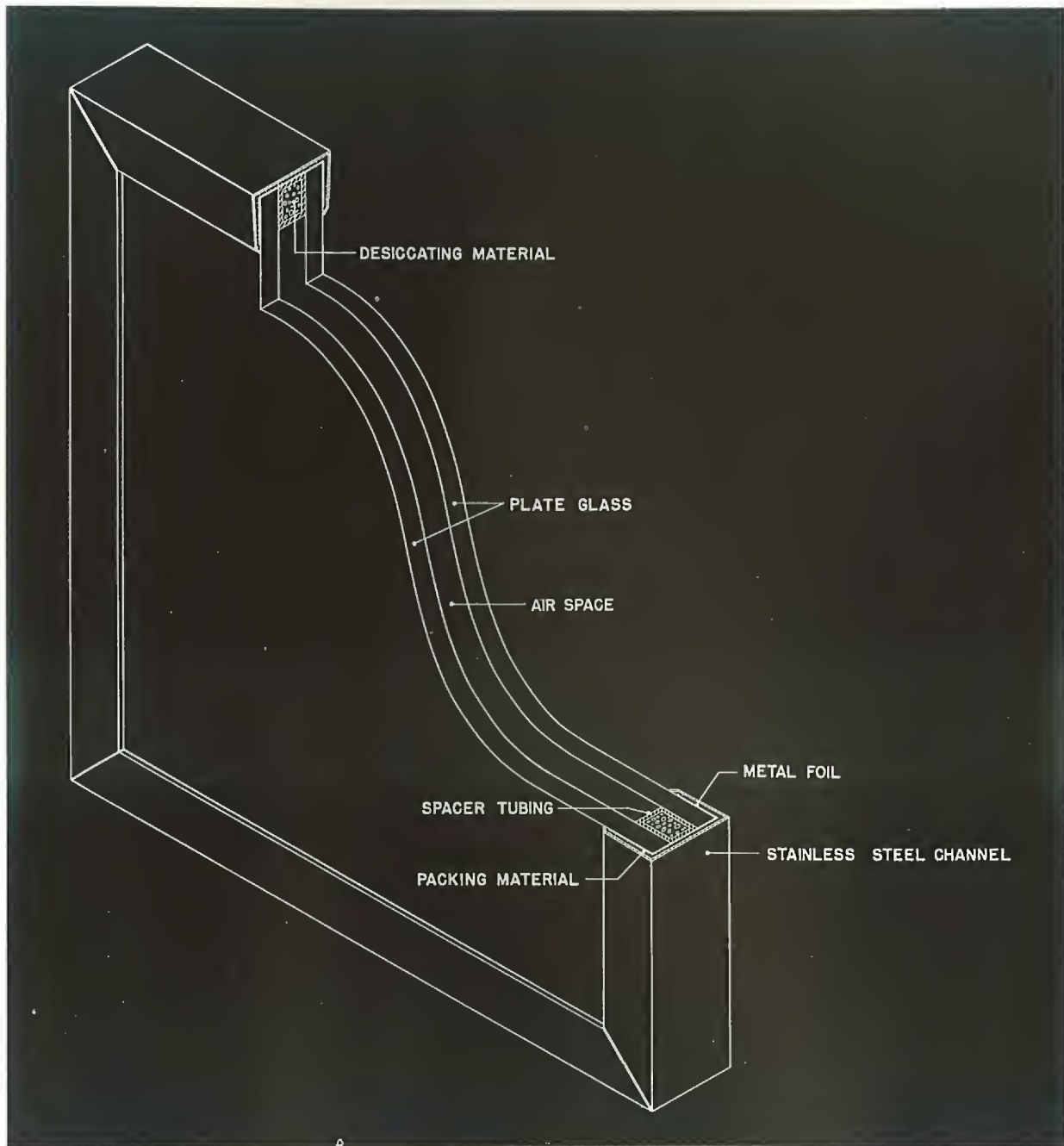
D

D-1

PREFABRICATED UNITS

Double Glazed Insulating Units

EVER since glass became available for closing window openings, people have been disturbed by the loss of heat through those window openings and the resultant condensation of moisture and frost upon the glass.



The double glazed unit offers a tremendous benefit to the homes of America. It efficiently insulates windows for the first time in history.

ANNOYANCE and often serious damage has resulted when the frost began to melt and the moisture ran down over the window sills. Consequently, there has always been a demand for some means of permitting light to enter, while at the same time avoiding loss of heat from the interior.

For many years this demand has been met by the installation of auxiliary glazing under the general heading of storm windows.

This solution of the difficulty has never been wholly satisfactory. The auxiliary windows are removable and it is the general custom to store them during the summer months. Also, while the windows are in place, they present a further housekeeping problem of having 4 glass surfaces to clean. Cleaning the storm windows is not always simple and frequently involves taking them down and reinstalling under decidedly adverse conditions. Often glasses are broken incidental to handling with consequent annoyance of re-glazing when the weather requires their use.

In many instances, particularly in some European countries, it was customary to place some moisture-absorbent material between the glasses and this added further complication although efficaciously preventing condensation of moisture in the interspace.

With the advent of air conditioning equipment, the demand for an insulating window has become more and more incessant. This demand is actually for an overall year-round insulation which shall effectively prevent heat loss in the winter and heat gain in the summer, whereby the capacity of the heating plant or of the cooling plant could be materially reduced and comfort conditions maintained at materially less cost than is at present possible where single glass panes are used in the windows.

For many years the Pullman cars used on all railroads have been equipped with double window installations. Originally, this construction was designed primarily for winter comfort, while in summer it was customary to open the windows and draw down a dust screen which was also permanently, though movably, installed between the window sash.

The railroads were the first large users of air conditioning equipment and the first double glazed integral unit in this field was developed by the Pittsburgh Plate Glass Company. The first large installation was made in cars built at Worcester, Mass. by the Pullman Standard Car Manufacturing Company for the New York, New Haven and Hartford Railroad.

These first units consisted of 2 lights of glass sealed into an extruded aluminum frame with chemically dry air in the space between the glasses. Subsequently, these units were equipped with a small receptacle containing a desiccant, or drying material, so that renewal of the desiccant could be made from time to time. This absorption of moisture is based on the fact that it is necessary to keep the water-vapor content of the air space below the dew point (condensation point) determined by the temperature of the outside glass. The initial production of the desiccated double glazed units comprised approximately 8,000 units. Now there are in service something more than 35,000 units.

More recently there has been developed the Double Glazed Insulating Unit which may be double or multiple glazed and which is provided with an internal desiccant, or drying agent, all held together and sealed gas-tight by means of a specially developed metal foil. This unit is the product of many years of research and practical testing. Thousands of these units are in service in railroad equipment, busses, military vehicles, residences, office buildings, airport control towers, refrigerated display cases, low temperature test chambers, store fronts and other installations. The units, compact and light in weight, are handled and installed just as ordinary glass. Units as large as 7 feet by 8 feet have been constructed with entire success. The method of assembly makes it possible to produce units of varying size and shape including curved units. They require no special servicing, since they are provided with an excess of drying agent incorporated in the seal of the unit. The units will withstand extremes of temperature in rapid alternation or wide differentials in temperature on opposite sides of the window. The temperature range under either condition is -80°F. to $+170^{\circ}\text{F.}$

The air space between glasses may be varied as required although a $\frac{1}{4}$ inch air space seems to afford the optimum value when all conditions of use and installation are considered. Increasing the air space beyond $\frac{1}{4}$ inch yields little additional insulation value while less air space materially reduces it.

Any desired combination of glasses may be used in assembling Double Glazed Insulating Units to obtain the benefit of the special characteristics of the components. Units fabricated with Solex Heat-Absorbing Glass in the outside light appreciably decrease solar heat gain in summer, thereby decreasing the load on air conditioning systems

and adding greatly to personal comfort. This construction is of special value in the southern or warmer parts of the country.

The insulation value of a double glazed unit with a $\frac{1}{4}$ inch air space between the glasses and an outside wind velocity of 15 miles per hour at a mean temperature* of 20°F. is nearly twice as great as that of a single glass. Where $\frac{1}{8}$ inch glass is used in the unit, a reduction of heat loss of some 44½ per cent may be anticipated while this reduction may be expected to be approximately 46 per cent, when $\frac{1}{4}$ inch glass is used.

At the time this is being written, there are some 11,000 of the new Double Glazed Insulating Units installed in the field, which during the past 5 years have given eminently satisfactory service.

The ultimate in double and other multiple glazed insulating units is still a matter of research and development, but at the present stage of the art, Pittsburgh Plate Glass Company Double Glazed Insulating Units are unsurpassed.

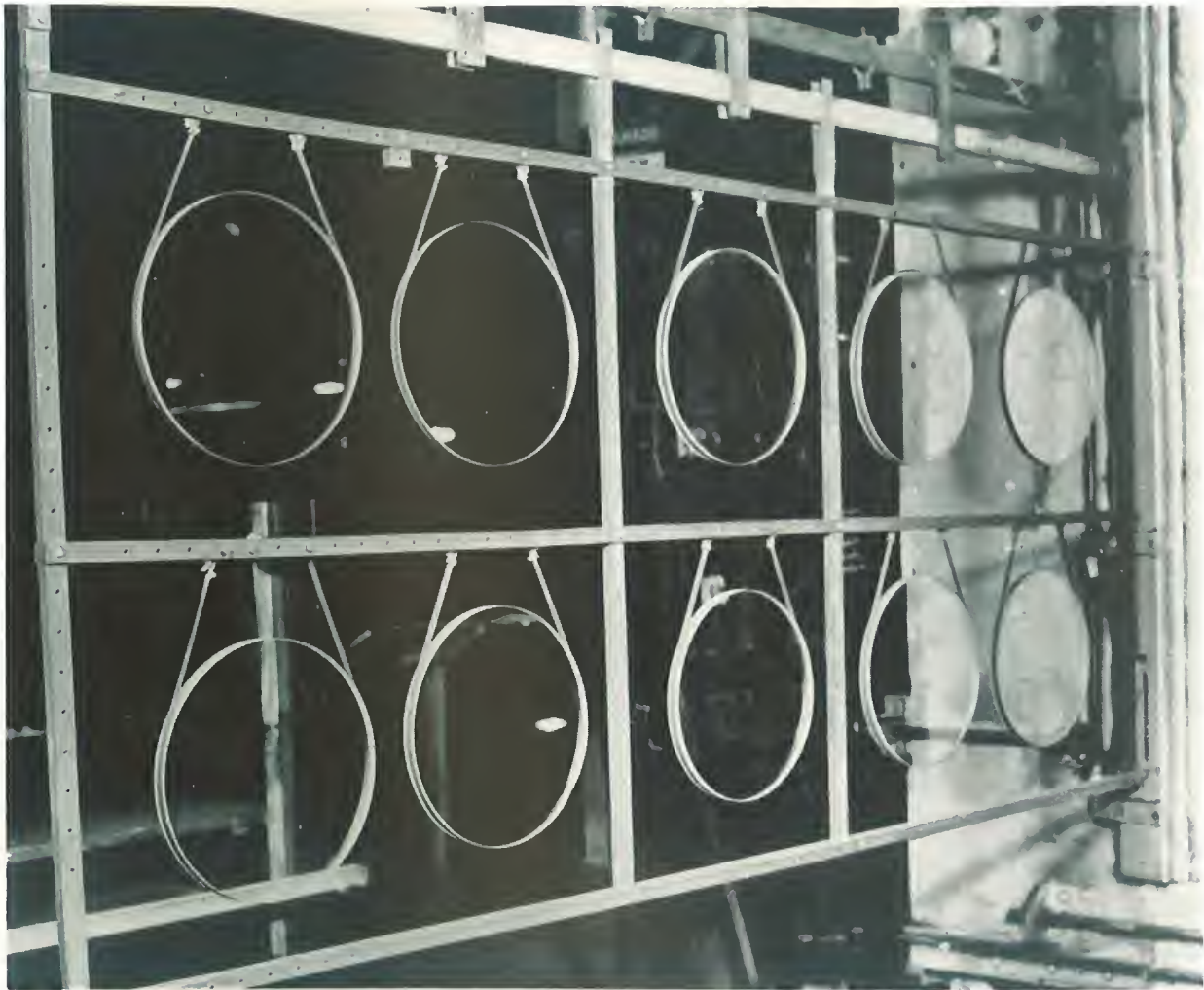
* Mean temperature here is $\frac{1}{2}$ the sum of indoor and outdoor temperatures.

D-2

PORTLIGHTS

Portlights

Herculite makes a considerable contribution to Shipbuilding



Tempered glass for portlights saves weight for ships in both weight of glass and in fittings for the portlight.

ORIGINALLY, only the heaviest glass was used for porthole glazing in order to withstand the impact of heavy seas. In time the use of circular glass of lesser thickness gradually developed and today, regular polished plate glass portlights are available as standard stock items in all diameters from 5 inches to 26 inches inclusive, and in all thicknesses from $\frac{3}{8}$ inch to $1\frac{1}{4}$ inch inclusive, in accordance with U. S. Navy Department Specification 12-G-4D.

The development of Herculite Tempered Plate Glass made possible a considerable saving in weight, without sacrifice of strength of portlights. This was a matter of considerable moment to the Navy and others, and today, Herculite Portlights are regularly produced in accordance with U. S. Navy Department Specification 12-G-6 in all full inch diameters from 5 inches to 26 inches inclusive, in all thicknesses from $\frac{3}{8}$ inch up to $1\frac{1}{4}$ inch inclusive, as may be required.

D-3

HERCULITE DOORS

Herculite Doors

A newcomer to the myriad of glass products, Herculite doors dominate the modern architectural field.



This famous baseball player executes a full swing at the door. The Herculite door is not impressed with a batting average of .350. The apparent crack at upper right is a photographic flaw—not retouched.

Until 1937, no one had ever seen an all-glass door, without a frame around the glass—and perhaps no one had ever thought of such a door. However, in that year, Herculite Doors entirely of glass became an accomplished fact. They were conceived in the course of a conversation between the president of a large corporation and one of the technical representatives of the Company discussing the expressed desire of the tenant for an all-glass, clear-view entrance to his building. The first installation was made in the entrance foyer for the Bank of the Manhattan Company. A well-known architectural journal has stated that Herculite Doors constitute one of the real contributions to architecture in modern times.

Herculite Doors consist of free standing, solid, all-glass panels of $\frac{3}{4}$ inch thick Herculite Polished Plate Glass essentially devoid of any surrounding frame or cross sash except that necessary for the accommodation of operating equipment. They constitute an integral part of the display facilities

of the establishment by affording uninterrupted view of the interior areas and thereby present a definite invitation to enter. They add materially to the effective illumination of building lobbies and lend a freshness, originality and beauty to entrance design which can be achieved only with polished plate glass.

Design possibilities with Herculite Doors are practically unlimited. They have been used with outstanding success for both exterior and interior installations in stores, restaurants, theaters, hotels, banks—in fact, in almost every type of building construction and many different types of enterprise. They are especially effective in attracting and holding favorable public attention when a bank of 2 or more doors is used at the entrance to any type of building.

The surface of the glass, before tempering, may be decorated as desired by any of the usual processes. There are, however, certain limitations on the decoration and fabrication of Herculite which



A wall of glass with a door of glass. But a short time ago this would have been called fantastic. A result of imagination and engineering working hand in hand.



This doorway becomes a show window. A beautiful instance of eating your cake and having it too. Modern business is quick to adopt the designers dreams made practical.

must be observed. See Section F-3. All fabricating and decorating must be finished before the glass is tempered.

Each door panel is equipped with especially designed metal fittings to accommodate the necessary builders hardware, such as Rixson pivot hinges, Glynn-Johnson door holders, Russell & Erwin locks, dead bolts, latches, etc. In some instances, these fittings constitute shoes or channels extending along the top or bottom edges of the glass, or of smaller fittings immediately at the corners of the door panel. The locks used have been especially developed for use in the top or bot-

tom channels, or in special lock housings where locks are desired in the conventional position adjacent to the center of the free edge of the door. Provision can also be made for push or pull bars, if desired.

All of these fittings are securely affixed to the glass by filling the fitting with a soft expanding material and then pressing the fitting into place, permitting the excess material to extrude from the clearance space between the fitting and the glass. The excess material is then trimmed off flush. This method of setting insures the permanent immovability of the fitting.

D-4

GLASS TANKS

Glass Tanks

Glass tanks, in this reference, is a generic term for industrial applications of glass to various types of conveying equipment, linings for existing tanks of other materials, and self-supporting glass tanks used as reaction vessels, storage containers, etc.



This tank has sides of $\frac{3}{4}$ inch Herculite. The bottom is tempered white Carrara for better observation of residue.

IN many instances existing tanks, vats or chutes may be lined with glass although it is generally better practice to replace old equipment with entirely new construction.

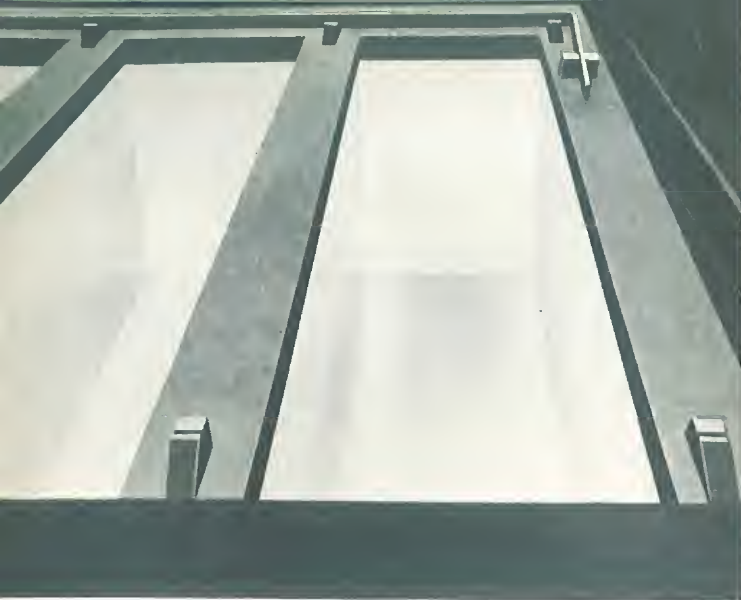
Pittsburgh Glass Tanks meet a need which has long been felt in industry and have become possible only since the development of adequate tempering processes. They are generally constructed of heavy plate glass Herculite designed to meet the demands of heavy industry. Herculite is especially suitable for the purpose because of its great strength and the high resistance of glass to chemical action.

Pittsburgh Glass Tanks are manufactured complete at the factory and shipped ready to be placed in service. They may be either free-stand-

ing all-glass, transparent tanks, usually moderate in size or they may be metal or wood shells lined with Herculite Glass and materially larger than the self-supporting all-glass type. In instances where the tank when completed would be too large for shipment, the glass linings may be installed at the job site.

Glass tanks are especially suitable for handling most mineral or organic acids, even including aqua regia. In most applications the temperatures may go up to 220°F.

In general, glass tanks are not suitable for use with solutions containing hydrofluoric acid in any concentration, solutions of most fluorine compounds, or caustic alkalis. Actual tests are required to establish the suitability and probable



Tanks of gleaming Carrara are returning their extra cost in part on every process cycle.

life of glass tanks for any individual application, particularly because industrial solutions are frequently mixtures of many compounds.

SELF-SUPPORTING TANKS

The self-supporting Pittsburgh Glass Tank offers the unique advantage of complete transparency which may be especially important in many applications. The method of joining these tanks makes it possible to meet unusually rigorous requirements such as would be involved in handling the more corrosive solutions, as, for example, hot chromic acid or hot nitric acid. They are constructed of Herculite Plate Glass of appropriate thickness for the size and service conditions. The bottom of the tank is usually equipped with a false inner bottom plate of Herculite White Carrara.

The fastenings are of monel metal, unless stainless steel is specified. The side panels are grooved to receive impregnated glass cloth gaskets. The gasket impregnating material will vary according to the solution to be used in the tank. In cases where tanks are intended to contain especially valuable solutions or materials which may be dangerous to personnel in the event of leakage or accidental breakage of the tank, glass tanks should be encased in wood or metal housings.

GLASS-LINED TANKS

Pittsburgh Glass-Lined Tanks are usually built with a steel shell. The steel shell is usually all-welded $\frac{1}{4}$ inch steel plate equipped with a 3 inch by 3 inch angle stiffener about the top edge which will serve as a base for any required coping. Where the size of the tank requires it, additional stiffen-

ing angles of adequate size may be welded around exterior of the tank.

The standard lining for these tanks is $\frac{1}{2}$ inch Herculite Plate Glass which is held away from the outer shell by special spacers. These spacers are designed to put compression on the joints, which are gasketed with glass cloth. The space between the glass and the supporting shell is filled with a continuous acid-resistant membrane developed by the Pittsburgh Plate Glass Company laboratory. The black acid-resistant membrane shows through the glass and gives the appearance of a black enamel surface.

This type of tank is regularly supplied with a replaceable wood coping. A glass coping may be supplied at some additional cost for those jobs where the top edge is not subjected to serious mechanical abuse.

The exterior of the tank and the coping receive two coats of acid-proof enamel before the tank leaves the factory. For certain applications, white or colored Carrara Herculite may be furnished.

Although glass tanks are not carried in stock, some of the parts are standard. Where dimensions may be held to multiples of 6 inches, shipment may be expedited. The maximum inside dimensions of the transparent all-glass tanks are 8 feet long by 5 feet 10 inches wide by 5 feet deep, while glass-lined steel or wood tanks may be furnished in sizes up to and including a maximum inside length of 12 feet.

In general, glass tanks are custom-built to meet special working conditions, and proper design of the tank requires complete information on the purpose of the installation, solutions to be handled, the temperatures involved, the desired dimensions of the tank, operating conditions, and the necessary number, location and size of outlets, drains or fittings.

CHUTES

As linings in conveyor equipment, glass offers many unique advantages among which low coefficient of friction, resistance to abrasion, and freedom from rust or similar deterioration are particularly noticeable.

The low coefficient of friction tends to reduce the angle of repose of most materials and thereby enhances the speed with which materials may be handled. Resistance to abrasion means greatly increased life as compared to metal which will in itself very materially offset any relative differences in initial installation costs. Freedom from corro-

sion eliminates the hazards of contamination of the materials handled through the chutes. Chutes may ordinarily be lined with annealed rough plate glass and, where desired for the sake of appear-

ance, may be lined with Carrara Glass. In some instances, particularly where hot materials are to be handled, it may be more desirable to line the chutes with Herculite.



First specially built pickling tank for steel wire containing hot sulphuric acid.

D-5

CARRARA GLASS PREFABRICATED UNITS

Carrara Glass Prefabricated Units

Carrara Glass has been widely used in the toilet rooms of office buildings, hotels, schools, hospitals and industrial establishments throughout the country.



This modern toilet in black and white Carrara possesses a high degree of sanitation. Such an installation is easily kept clean.

IN MOST if not all installations involving the use of Carrara Structural Glass, prefabricated or ready built units play an important part. Their use simplifies the installation work and eliminates tedious and difficult field fabrication.

Carrara Structural Glass Prefabricated Units are used throughout the country in homes, schools, hospitals, office buildings and industrial establishments. They may be obtained in standardized units for toilet rooms, bathrooms, shower stalls,

toilet stalls, or kitchens, or they may be prefabricated to designs and sizes compatible with the specialized installation desired.

This type of installation, aside from the ashlar and trim members of the wainscoting, involves the use of other component structural units—stiles, partitions (both laminated and solid) and lintels. These units are shipped from the factory, completely prefabricated and ready for installation with a minimum of field work.



These gleaming Carrara walls and enclosures retain their luster indefinitely with little maintenance.

STRUCTURAL UNITS

Carrara Structural Glass Prefabricated Units are built up of a number of structural units, each of which is completely prefabricated to meet the requirements of the complete installation.

Ashlar are furnished in $1\frac{1}{32}$ inch thickness only, in all colors except orange and wine. All edges are ground. They are fabricated in whole inch measurements only, to a minimum dimension of 8 inches and a maximum dimension of 24 inches.

Base, cap and trim members are available in all colors in $\frac{1}{16}$ inch and $\frac{3}{8}$ inch thickness, and in $1\frac{1}{32}$ inch thickness in beige, blue, forest green and wine, all in lengths from 32 inches to 72 inches, and in width or height up to 12 inches.

Panels are also used in wainseots, where preferred to the ashlar treatment. They are available in $1\frac{1}{32}$ inch, $\frac{1}{16}$ inch and $\frac{3}{8}$ inch thickness, depending primarily on the size of the panel.

Partitions are supplied in $\frac{3}{8}$ inch thickness, polished on both faces, either solid pieces, or two pieces of $\frac{7}{16}$ inch thickness, laminated together. These partitions are furnished completely fabricated and drilled for erection and installation of hardware and accessories. They are available in ivory, gray, tranquil green, white and black.

Stiles and lintels are fabricated in $1\frac{1}{4}$ inch thickness, polished on both faces, in ivory, gray, tranquil green, white and black. They are completely fabricated and drilled for erection.

Hardware required for the installation of Carrara Structural Glass Prefabricated Units may be obtained as part of the packaged prefabricated unit, but as a rule should be procured direct from the hardware manufacturer.

TOILET ROOM COMPARTMENTS

In the field of prefabricated toilet room installa-



Black Carrara stiles and lintels combined with white Carrara partitions lend beauty to this installation.

tions, there are the usual or metropolitan type and the government type. In the metropolitan type the compartment may be left without a lintel or the prefabricated solid Carrara lintel may be used where desired. Rigidity of construction is obtained

by letting the stiles and partitions into the floors and walls at least $\frac{3}{4}$ inch so that they may be held straight and true with a bond of plaster of Paris.

In the government type of toilet compartment the partitions are full floating. The weight of all

partitions is supported on metal legs at front and back. The end wall is supported on a metal leg at the rear and the front is held on a metal saddle fastened to the stile. All stiles extend through the finished floor and rest on the rough floor slab. Metal lintels and channels over the top of the partition act as braces to insure a trouble-free installation. This produces a stress-free construction which is intended to compensate for any settling of the building.

In most instances, the partitions are constructed of two pieces of Structural Carrara Glass laminated together by a special factory process which assures durable permanent adhesion.

The toilet room installation may also include walls, either ashlar type or large slabs. In either case, the ashlar or the large slabs are prefabricated to exact dimension so that installation may be carried out easily, and quickly.

SHOWER ENCLOSURES

Prefabricated glass showers are designed to meet the demand for a good inexpensive shower which may be installed quickly and economically. A maximum of five to a minimum of three pieces of glass form the complete unit. Prefabricated shower enclosures are designed in four types to accommodate the requirements of present-day housing. Each type is available in two price ranges, one utilizing tempered or Hereulite Glass for strength while the other uses regular Carrara Glass and rough plate glass which are entirely satisfactory for normal use. Each shower enclosure is packed as a unit in a single box, including all glass and necessary setting materials as well as curtain rod and china soap and grab. The glass is completely fabricated at the factory with all cut-outs and drilled holes to specifications.

Corner showers are supplied in Types 1 and 3. In these, the stiles are of rough plate glass, permitting light to enter even when curtain is drawn. Wainscots can be tempered or regular Carrara. The bent rough plate glass stiles of Type 1 cannot be tempered, but the straight stiles of Type 3 may be either tempered or regular.

Square showers, known as Type 2, may have either tempered or regular glass wainscot, but stiles are always tempered. In Type 4 the stiles are eliminated for greater economy and the curtain rod is set farther back in order to keep water from splashing out. When the washbasin is set on partition wall, the same plumbing pipes may

serve both shower and lavatory, satisfactorily.

Shower receptors must be procured from other sources and under proper direction may be built in place. Every care should be exercised to be sure that the shower receptor shall be watertight in order to avoid serious damage which may result from any leakage which may occur.

READY-BUILT BATHTUB WAINSCOT

Carrara wainscot to surround recessed bathtubs is designed primarily for new construction only. These Carrara wainscots are entirely prefabricated at the factory and are inexpensive and easy to install. They bring all the beauty of Carrara construction to the low cost home.

The panels are mounted on plasterboard, which may be attached directly to the studding.

Soap and grab are furnished where required for heights over 16 inches. All necessary openings for plumbing or soap and grab are provided in the prefabricated units. The whole wainscot is shipped to the building job as a complete unit ready for immediate installation.

READY-BUILT STOVE SPLASH

The Carrara Structural Glass stove splash affords an excellent and inexpensive way to protect the wall area behind the stove from grease, grime and heat and to add appreciably to the appearance of the kitchen. The Carrara stove splash is mounted on plasterboard similarly to the Carrara ready-built tub wainscots and finishes flush with the face of the plaster wall.

Obviously, although these units are described as ready-built stove splash units, they may have many other applications about the home.

Any of these Carrara Structural Glass prefabricated units may easily be kept clean by wiping with a damp cloth.

Walls of Carrara Structural Glass can lift any bathroom or kitchen from the commonplace and lend dignity, sparkle and new life.

Few can resist the appeal of Carrara Structural Glass. Its warm color tones are cheerful and inviting. The smooth polished surfaces afford an ease of cleaning which persists through the years. The beauty of Carrara is permanent. Dirt and deterioration will not harm the brilliant finish. It does not chip, stain, craze or absorb odors or moisture. It is truly a modern material which places a distinctive permanent improvement within easy reach of the average family.

SECTION "E"

OTHER GLASS PRODUCTS

E-1

PC GLASS BLOCKS

E-2

PC FOAMGLAS

E-3

MISSISSIPPI GLASS COMPANY

E-4

PRESSED PRISM PLATE GLASS COMPANY

E-5

LEADED GLASS

E-6

OTHER FLAT GLASSES

OTHER GLASS
PRODUCTS

E

E-1

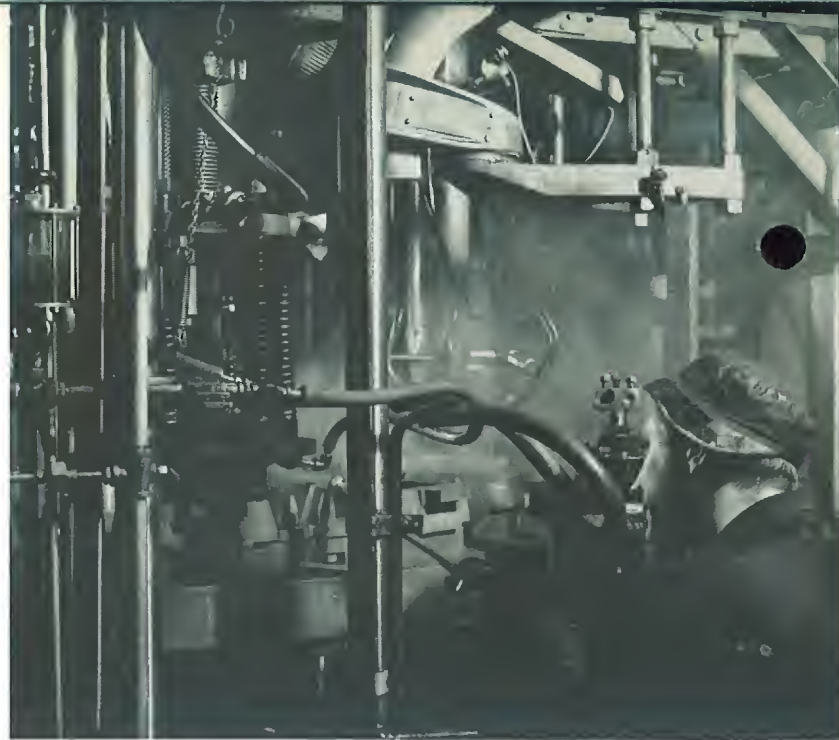
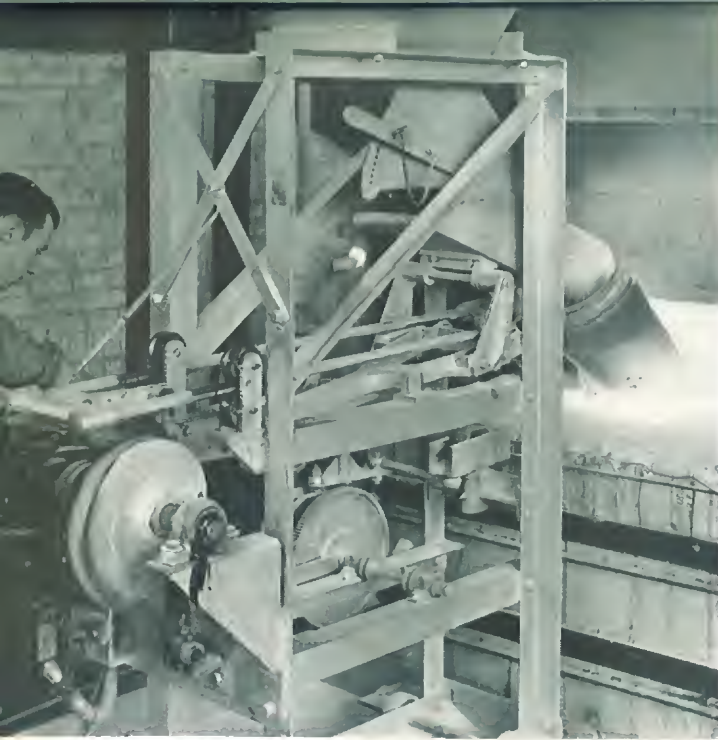
PC GLASS BLOCKS

PC Glass Blocks

Glass Blocks — hollow glass blocks — are a relatively new article of commerce. They are one of the products of the Pittsburgh Corning Corporation, whose factories are located at Port Allegany, Pennsylvania. The company, incorporated in 1937, is jointly owned by Pittsburgh Plate Glass Company and Corning Glass Works.



A structural glass unit which combines
Beauty, Utility, and Conservation of energy.



A constant stream of raw batch is promptly converted to the molten substance to feed this block forming machine.

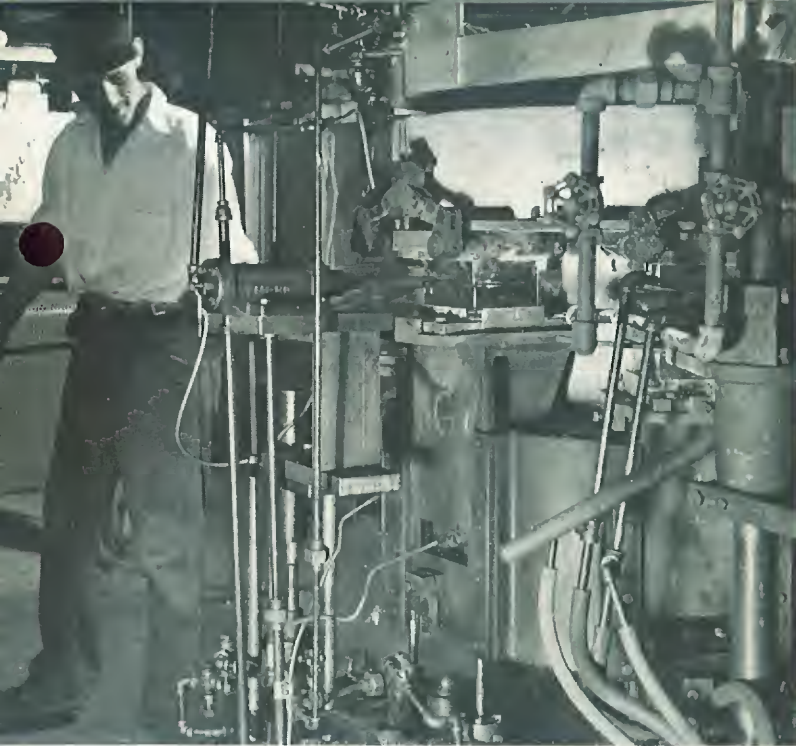
THE manufacture of glass blocks is carried out in a single building especially designed to accommodate a full production line from raw batch to finished packed product ready for shipment.

The batch materials consisting of sand, limestone, soda ash, and nepheline syenite from which is derived potassium, aluminum and some additional soda, are stored in large concrete bins much as is done in other glass factory batch houses. Each bin is equipped with its own set of scales and the desired quantities of material are weighed out, each into its own scale hopper, which is then discharged into a conveyor which carries it to the batch mixer and thence to the melting tank.

The glass is melted in a typical tank furnace approximately 18 feet wide by 36 feet long with a melting capacity of approximately 100 tons per day. Under standard conditions the glass is melted entirely by the use of natural gas. However, there is available a fuel oil system which may be used in the event of a natural gas shortage. The glass is unusually clear and white having excellent weather-resistance and a reasonably low coefficient of expansion. The batch materials are fed into the tank continuously so that there is a blanket of raw batch covering the first portion of the melting zone in the tank. This system of feeding provides a thin layer of raw batch which melts rapidly and uniformly and reduces the hazard of unassimilated material passing beyond the melting zone. The working end of the tank is equipped

with three delivery channels or necks varying from 10 to 14 feet in length, which materially assist in cooling the glass to a satisfactory working temperature. At the outer end of each of these delivery necks, there is provided an unusually large Hartford-Empire feeder which delivers measured quantities of glass to the adjacent pressing machine. The glass flows around a clay plunger into a sillimanite orifice block and as the refractory plunger moves down, a measured quantity of glass is forced out through the orifice. At the end of the downward stroke of the plunger, the mass of glass in the gob has assumed a pear shape with the narrow portion close to the orifice block. At this instant, a pair of heavy water-cooled shears automatically snip off the neck of the gob and exactly the correct quantity of glass for one half block drops through guide chutes into a waiting mold on the revolving table of an automatic pressing machine. The upward movement of the plunger draws the glass back with it in the orifice until fresh glass begins to flow. This action insures that there shall be no chilled portions of the glass to mar the next block.

The pressing machinery consists of a 12 station revolving table carrying 12 female molds. Each mold consists of 2 carefully machined cast-iron parts, one of which establishes the size of the face, including the flange, while the other determines the walls and thickness of the flange. This construction enables easy removal of the



Some man power, a lot of compressed air to drive the mechanism, blowers to cool the overhot molds, make possible the quantity production of Glass Blocks.

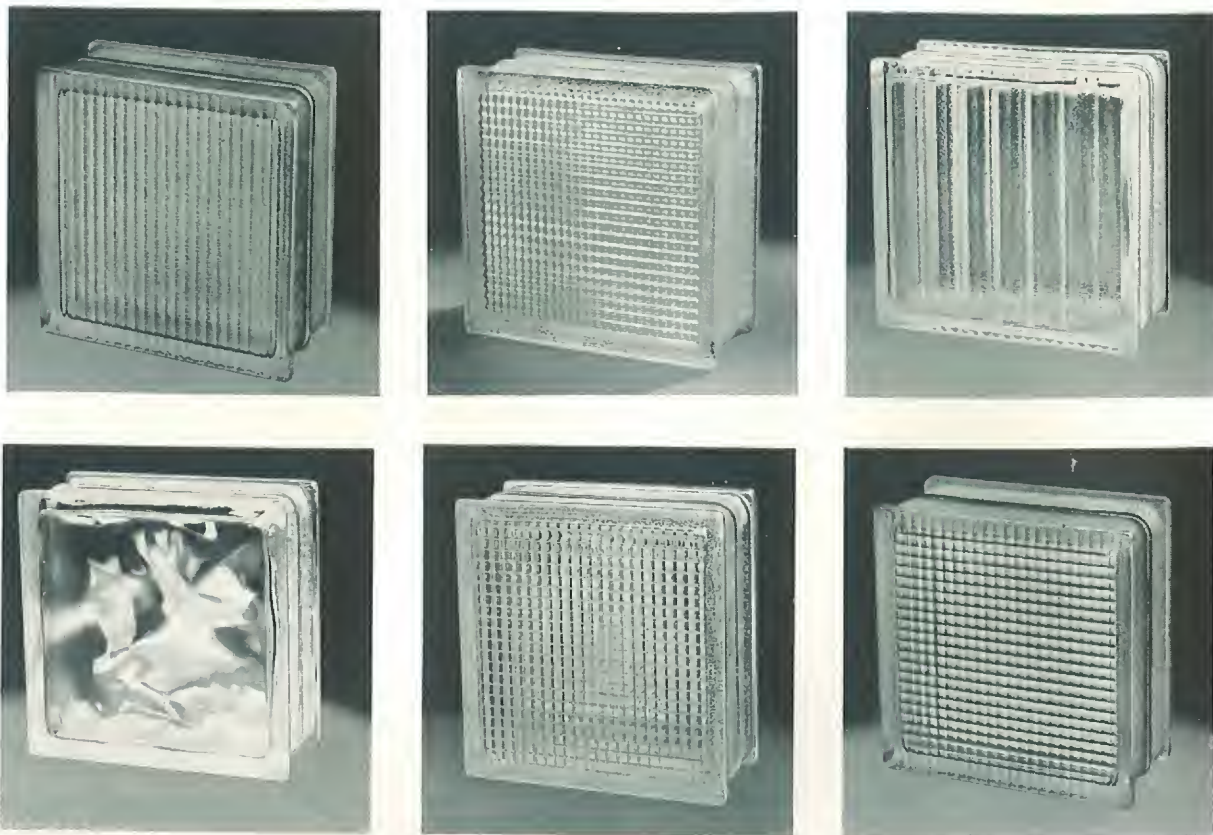
formed block from the mold. Each mold moves successively into position under a plunger equipped with a male mold, machined to produce the configuration desired on the interior of the block. The entire operation of the machine, including the feeding of the glass and the final sealing of the 2 halves of the block is timed by the motion of the plunger mold just described. At the station before the pressing action takes place, the gob of glass drops into the mold with the upward motion of the forming plunger. The mold and glass now move to station No. 1 where the plunger is forced down and the male mold squeezes the glass out to form half of a hollow block. The plunger is automatically retracted and the table moves on to set the next mold into position under the plunger. From 8 to 12 blocks are pressed each minute, the number depending upon the size of the finished block.

The glass remains in the mold for approximately half a revolution of the turntable. This carries the mold to station No. 6 or farther, depending upon the size of the block being made. At each station air is blown into the mold and glass, to assist in cooling the glass to rigid shape. At the proper station, the vertical portion of the mold which has formed the sides and top of the flange of the half block is automatically raised. The half block is picked up by a workman using asbestos-covered tongs and placed upon a conveyor which moves it to the sealing machine.

The sealing machine is a 6 station revolving mechanism in which the 2 halves of the block are sealed together. Each station consists of a pair of automatic chucks or holders, each of which will receive a half block in exact register, one above the other. The upper chuck is in fixed position, while the lower chuck may be moved upwardly to bring the half blocks close together and ultimately to squeeze them together.

As the conveyor brings the pressed shapes to the sealing machine, the operator picks up a half block, turns it open side down and sets it in the top chuck. This top chuck is set to automatically grip the block at a predetermined movement in the cycle. The next half block is moved directly, open side up, to the bottom chuck. The half blocks are securely gripped by the chucks and held in exact register throughout the balance of the process. The operation of feeding the glass into the sealing machine requires considerable dexterity and speed since there is available only a minimum of time.

Almost as soon as the half blocks are in place, they move forward to the next station. Here a special type of gas burner is so arranged that flames from the top of the burner impinge upon the bottom edges of the upper half block while other flames at the bottom of the burner impinge upon the top edges of the lower half block. This begins to heat the edges to a high temperature with the half blocks approximately a foot apart. The third



Here are shown six of the ten standard patterns of PC Glass Blocks:
Bristol, Essex, Saxon, Decora, Prism-Light-Diffusing and Druid.

and fourth stations are similarly equipped and as the blocks move from the fourth to the fifth station, the edges have become white hot. In moving from the fourth to the fifth station, a specially designed air-blast nozzle moves very rapidly forward between the 2 half blocks and the products of combustion are blown out from the bowls by jets of essentially chemically dry air.

As the blocks enter the fifth stage the chuck is suddenly forced upwardly by the action of a compressed air hydraulic cylinder so that the edges of the half blocks are approximately $\frac{1}{4}$ inch to $\frac{1}{2}$ inch apart. The sections have become highly heated which tends to superheat the air in the space between the blocks and expand it. The expanding air almost completely escapes from between the half blocks in the brief time during which they are held a slight distance apart and then automatically the motion of the hydraulic cylinder forces the sections of the blocks together while the edges of the side walls are still hot enough to weld into each other.

At this stage, the air pressure within the block and the atmospheric pressure surrounding the

block have become approximately equal and the thickness of the wall prevents any further tendency for the seal to either blow out or suck in.

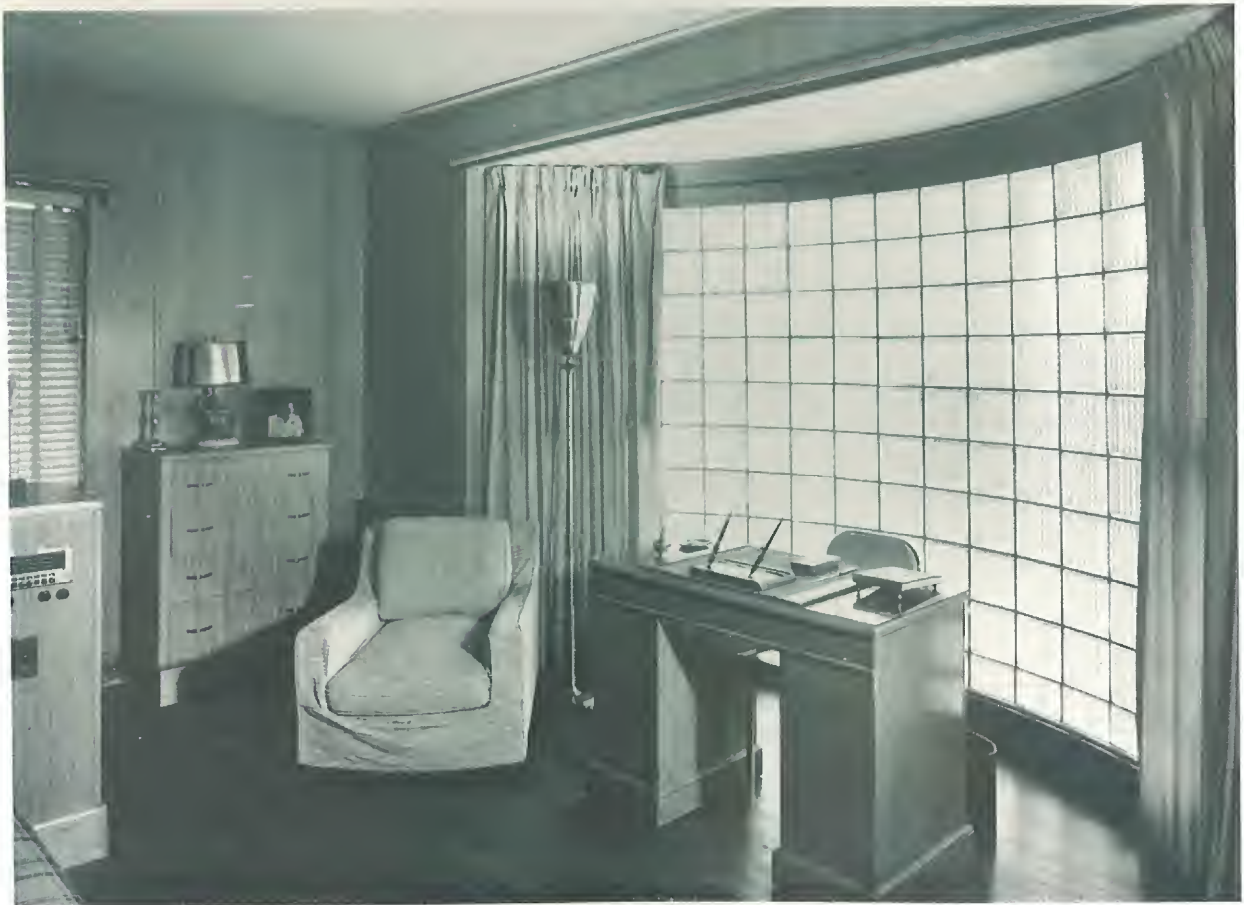
As soon as the seal has become sufficiently rigid, the bottom chuck is automatically released from the lower half of the block and the completed block remains suspended in the top chuck. The block now moves to the sixth and last station where the operator removes it from the chuck and sets it upon the conveyor to pass through the annealing lehr.

In the lehr, the blocks are thoroughly annealed so that the welded joint just described is free from any strain which would tend to rupture the joint, and the blocks are allowed to cool to nearly room temperature. As the blocks cool, since the enclosed volume is fixed, the pressure of the air within the blocks must diminish proportionately to the absolute temperature with the final result that the pressure is reduced to very nearly $\frac{1}{2}$ atmosphere—which is another way of saying that the walls of the block enclose a partial vacuum.

As the blocks leave the lehr mouth, inspectors examine them critically for flaws, and any defec-



The almost perfect translucence of the Argus pattern compares with the beautiful transparency of the Vue Block.



A beautifully conceived, magnificently illuminated, comfortable home workroom.



An almost solid wall of glass block affords splendid daylight illumination and almost perfect insulation.

tive blocks are discarded and returned to the cullet pile for remelting. The good blocks are loaded onto skips which are moved from time to time to the edge coating machine.

The edge coating machine consists of a very light, large diameter circular table equipped about the circumference with spindles upon which the blocks may be set so that the edges of the block are vertical, and exposed. As the table

revolves, a spinning motion is imparted to the blocks and the edges of the blocks are thoroughly covered with a resilient coating of vinylite plastic and a fine spread of sharp-grained sand or marble dust. This coating insures a satisfactory permanent bond between the glass blocks and the mortar joints. The spindles are so arranged that as soon as the edges of the block have been coated, the uncoated faces of the block are uncovered, so



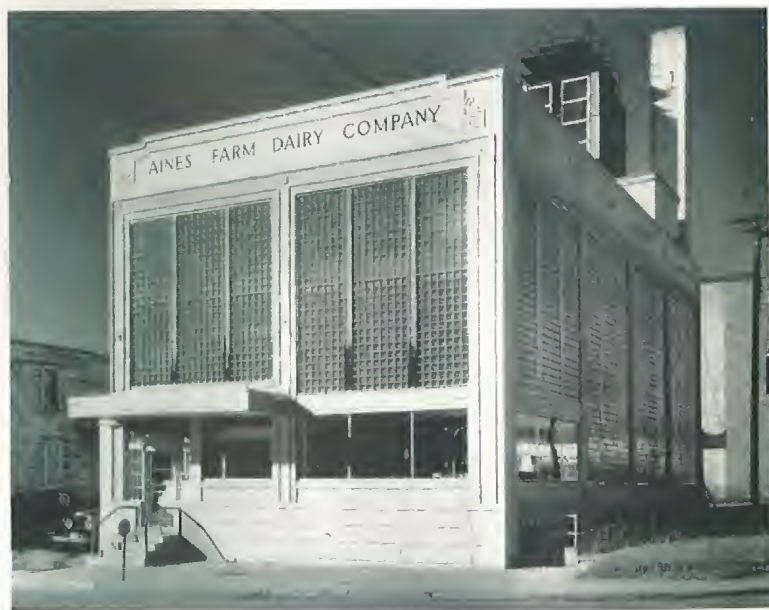
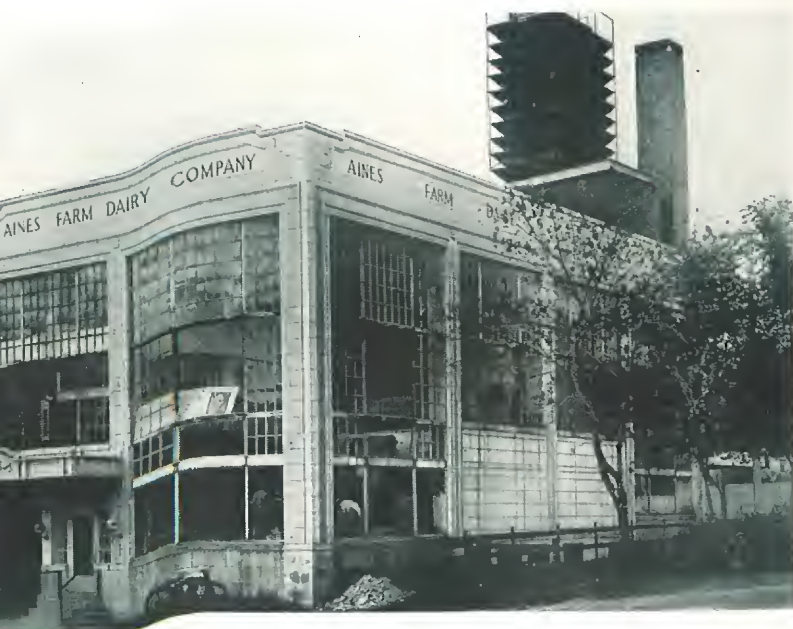
PC Glass Blocks raise this facade out of the commonplace into an artistically inviting exterior.

that the attendant may move the block from the edge coater to a conveyor which carries the block to the packing department. The blocks are packed in cartons according to size so that twelve $5\frac{1}{4}$ inch blocks, eight $7\frac{1}{4}$ inch blocks, or three $11\frac{1}{4}$ inch blocks are packed in the same size container.

PC Glass Blocks are regularly available in 10 different designs known as Argus, Argus-Parallel Flutes, Decora, Reeded Decora, Saxon, Druid, Bristol, Prism Light Directing, Essex, and Vue Block. Vue Block are obtainable only in the $7\frac{1}{4}$ inch size.

PC Glass Blocks are made as square blocks, corner blocks, and radial blocks as indicated in the chart shown on the next page. Square blocks are available in the $5\frac{1}{4}$ inch, $7\frac{1}{4}$ inch and $11\frac{1}{4}$ inch sizes; corner blocks in the $5\frac{1}{4}$ inch and $7\frac{1}{4}$ inch sizes; and radial blocks in the $7\frac{1}{4}$ inch size only. As shown by the accompanying chart, blocks of these dimensions are not available in all patterns.

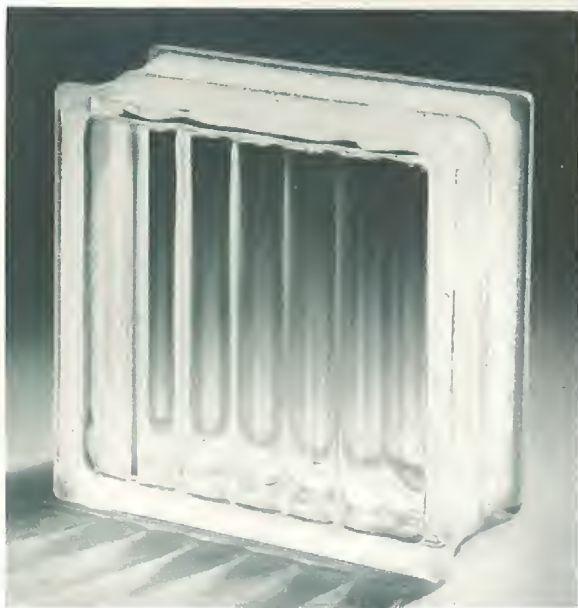
Drawings of square, corner and radial blocks are shown in Section J-10. Methods of installation and limitations are discussed in Section H-11.



Not plastic surgery—merely a face lifting job to rejuvenate the building.

	SQUARE BLOCKS			CORNER BLOCKS		RADIAL BLOCKS
	5 $\frac{3}{4}$ "	7 $\frac{3}{4}$ "	11 $\frac{3}{4}$ "	5 $\frac{3}{4}$ "	7 $\frac{3}{4}$ "	7 $\frac{3}{4}$ "
Argus	x	x	x	x	x	x
Argus Parallel Flutes	x	x	x			
Decora	x	x	x	x	x	x
Reeded Decora	x	x	x	x	x	x
Saxon	x	x	x	x	x	x
Vue		x				x
Essex		x				
Bristol		x			x	x
Druid		x			x	x
Prism Light-Directing		x				

"X" indicates availability of the different types of block.



Argus, Parallel Flutes.



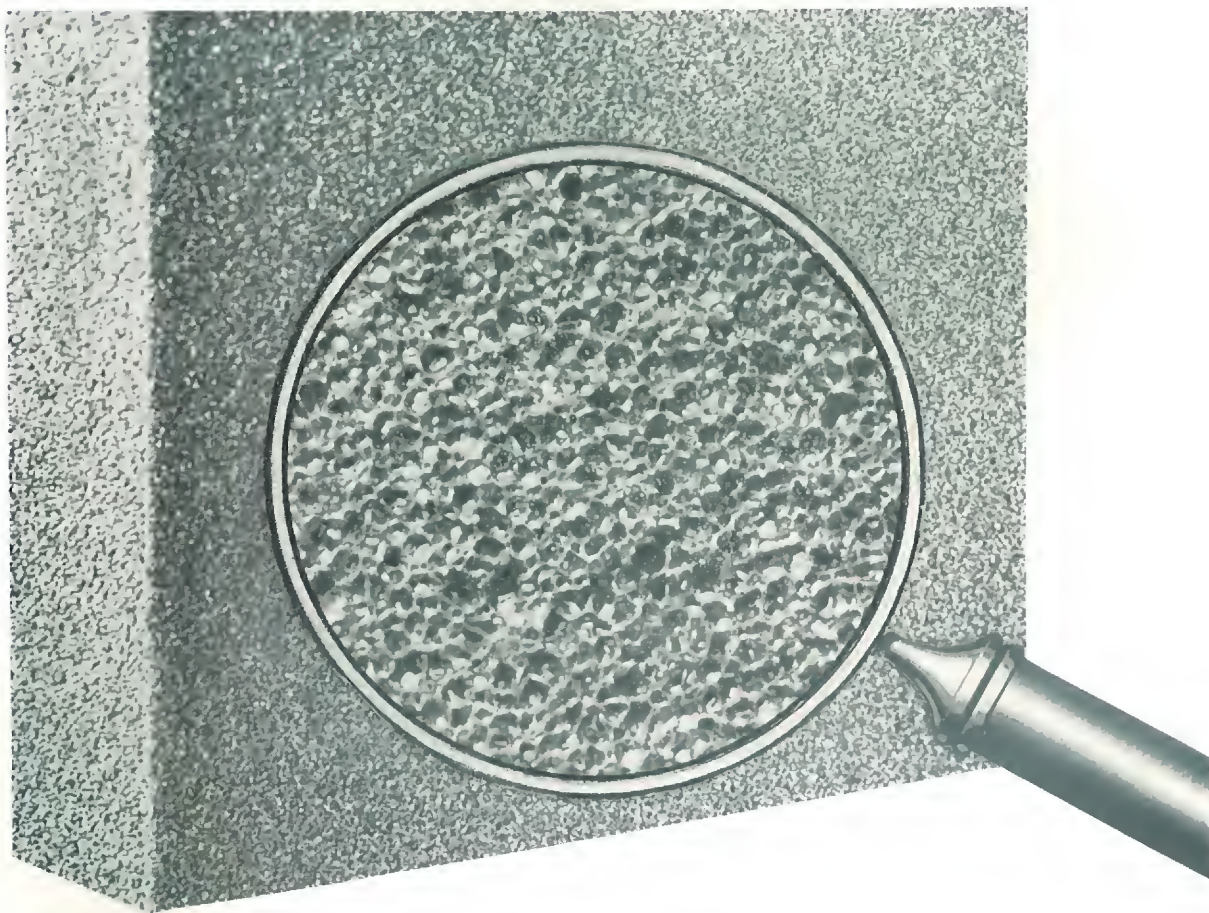
Reeded Decora.

E-2

PC FOAMGLAS

PC Foamglas

Many different types of glass insulating products have been proposed from time to time, and some have been carried beyond the development stage to become actual commercial products. However, it remained for Pittsburgh Corning Corporation to develop and merchandise an entirely new glass insulating material which is difficult to recognize as glass.

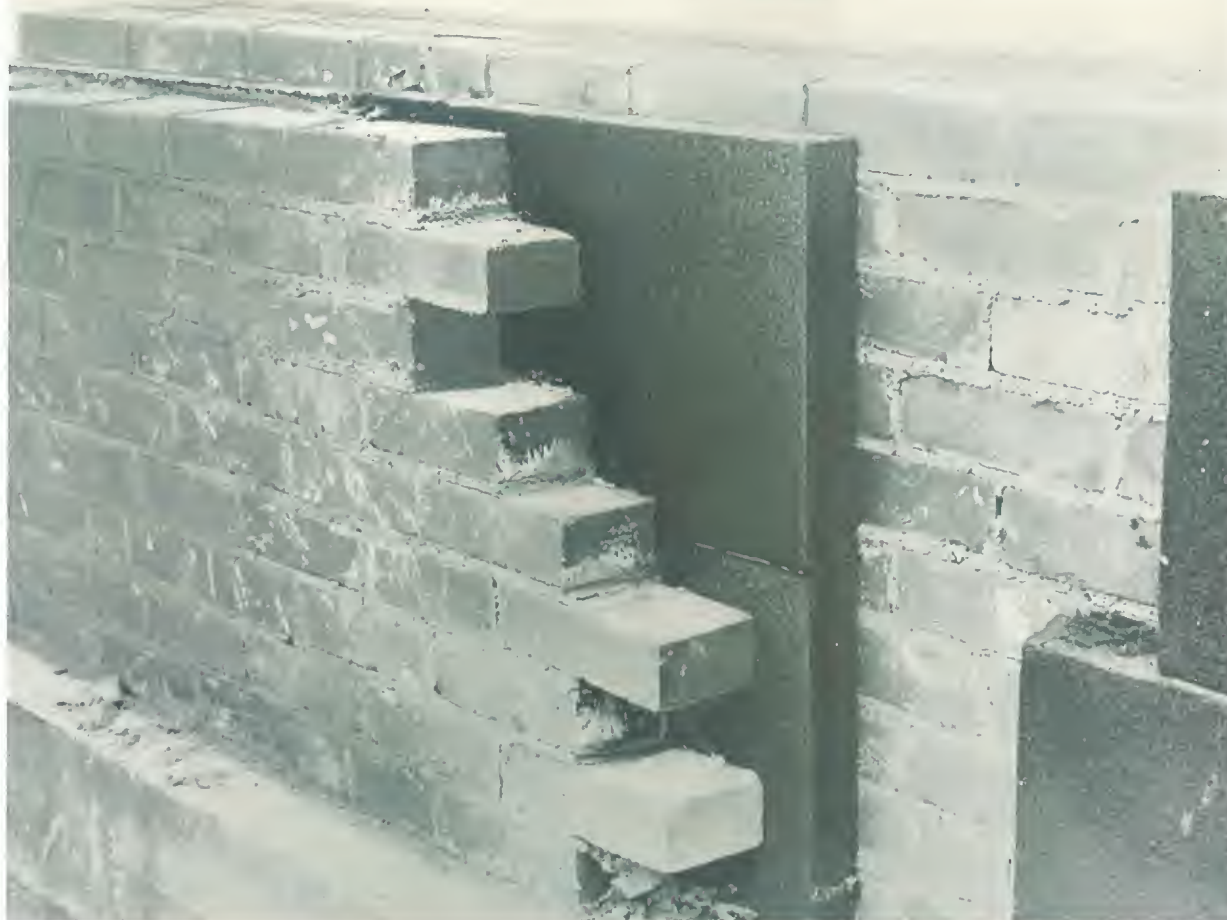


Solidified cells, billions of them, of permanent glass do a businesslike job of insulating. Foamglas is free from the ills of ordinary insulating materials.

IN the processes of glass founding, large volumes of glass foam appear on the surfaces of the melt. This foam intrigued the imaginations of engineers who saw in it a possible insulating product. Efforts were made to produce a cellulated glass, by making the molten glass boil under a vacuum, and by

introducing ebullient materials into the original glass melt. All of these efforts proved fruitless, until the engineers of Pittsburgh Corning Corporation developed a technique which proved practical in producing a commercial product.

PC Foamglas has progressed a long distance



A Foamglas core wall lays up in a quick efficient manner—readily cut, it presents a minimum of trouble and inconvenience to the mason.

since the initial efforts to produce cellulated glass on a commercial basis. The development has taken place almost entirely at Port Allegany and has resulted in the construction of a full scale plant alongside the glass block factory. The plant consists of a one-story building containing approximately 50,000 square feet of floor space and designed to accommodate 6 complete process units which should ultimately have a combined capacity of approximately 50,000 board feet of Foamglas per day. Three of these units have been in operation for several years and an additional unit is being completed as this is being written.

The raw materials used are an especially prepared cullet and finely divided carbon. The cullet is stored in bulk and particular care is exercised to prevent any foreign matter from contaminating it. The carbon is received and stored in ten pound moisture proof paper bags.

The cullet is thoroughly dried in a counter-current rotary type drier constructed of steel and fired by natural gas. The cullet is fed into the drier at a fixed rate and the dried cullet is carried on a belt elevator to an intermediate storage and supply hopper.

The dried cullet is weighed from the cullet bin into a scoop feeder into which the carbon is weighed manually. The mixture of cullet and carbon is intermittently fed to a continuously operating ball mill. The ball mill is a steel shell 8 feet in diameter by 14 feet long, lined with 4 to 5 inches of buhr-stone. Flint pebbles approximately 2 inches in diameter are used to grind the material as it travels down the length of the mill. Approximately 95 per cent of the final mix is sufficiently fine and the remaining 5 per cent is recycled through the grinder. The mixed batch is carried by a bucket elevator to a steel batch bin. A vibrating feeder conveys the finely pulverized mixture to automatic weighing scales located near the furnace entrance.

The molds in which the cellulation of the glass is completed are pushed manually along an idler-roller conveyor passing under the scales and in front of the charge doors of the cellulating furnaces. The molds are made in 2 sections consisting of upper and lower halves, tapered in both width and length to facilitate removal of the finished block of Foamglas after firing. The interior of each mold is coated with a special mixture to

keep the powdered glass from sticking to the mold. As the mold passes under the scales, it is manually centered under the discharge chute and the already weighed charge of mixed batch permitted to fall into the mold. The mold is moved away from the loading machine and the top half set in place.

The mold is now moved by hand along the conveyor to one or another of the cellulating furnaces. Each furnace is approximately 60 feet long and is kept constantly loaded with charged molds. As the new mold is set into the furnace, a corresponding finished mold moves out of the discharge end.

In passing through the cellulating furnace, the finely powdered charge has expanded and risen to completely fill the mold. At this point, the Foamglas block closely resembles a mass of black foam and its density has changed from approximately 50 pounds per cubic foot to approximately 10 pounds per cubic foot.

As the molds move out of the cellulating furnace, they are received by attendants or strippers who rap the Foamglas block free of the mold. The stripped molds are placed on a mechanically operated roller conveyor which carries them back to the loading scales.

The stripped Foamglas blocks or cakes are moved manually across a narrow passage where the attendants stand, to the annealing furnace directly opposite the discharge end of the cellulating furnace. The annealing lehr is approximately 130 feet long, gas fired, and of a highly special design to insure full anneal throughout the block. This is an especially exacting operation because of the highly insulated block itself and the consequent difficulty of maintaining equalized temperatures throughout the mass.

The annealed rough blocks of Foamglas are manually loaded onto skips and moved to the final trimming machines where each block is individually cut and shaped, first in a face trimmer and then an edge trimmer. The trimming machines cut the blocks by means of rotating abrasive wheels which are essentially circular saws.

The base size of the finished blocks is 6 inches by 12 inches by 18 inches. They may be easily cut on a band saw to produce lesser thicknesses where required. Standard cardboard cartons are used to pack the final product for shipment after each block has been inspected.

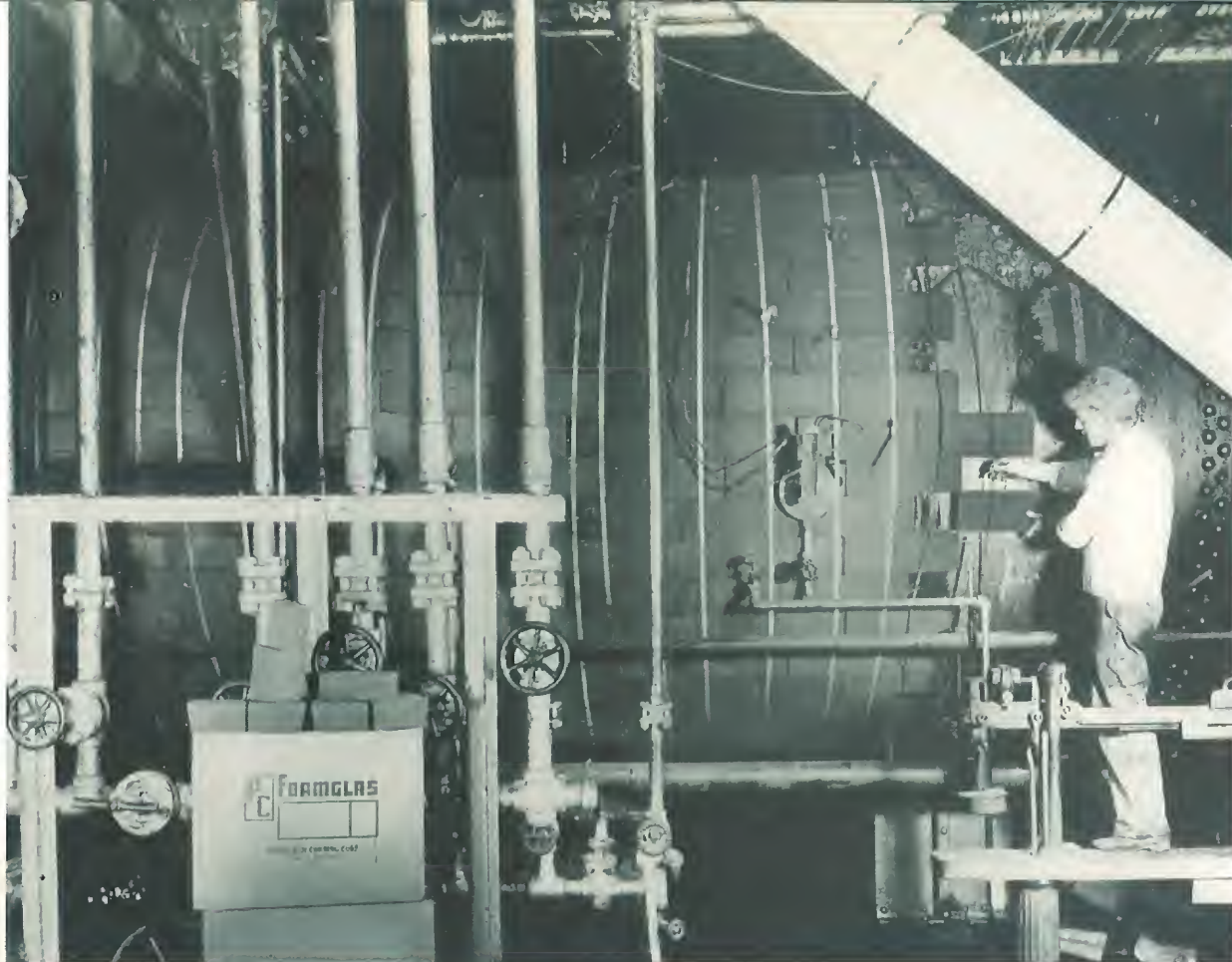
A dust collector system keeps the entire plant effectively clean and free from dust in spite of the fact that several of the operations are extremely dusty in character. Each point where dust may



Foamglas, the supplying layer shown at the bottom of both pictures undergoes above, a load bearing test and below, an impact test.

be generated is connected by ducts to the large bag-type dust collector. The dust from this collector and the tailings from the trimming machines are of no further use and at present are disposed of on the waste pile.

Careful control of the temperatures in the cellulating and annealing furnaces is made possible by recorder control instruments housed in a cen-



The availability of Foamglas in different sizes makes it an efficient insulating material for tanks and vats and similar containers.

trally located glass enclosed control room, thoroughly insulated with Foamglas. The temperatures at a number of stations on each furnace and lehr are automatically recorded and adjusted. Numerous additional temperatures may be read selectively from time to time, to determine the temperature of the Foamglas blocks as they move through the furnaces.

By locating this control room centrally above the operating floor, a good view of the entire plant is obtained from this station.

The research and factory control laboratories for both the glass block and Foamglas plant are housed in a building adjacent to the glass block factory building. A comprehensive program of research is under way directed particularly toward finding new ways for improving the unique Foamglas product, utilizing the waste and developing the proper application of the 2 products to many additional commercial uses.

Foamglas is packaged in five standard carton sizes convenient for shipping and handling on the job. The smaller thicknesses are cut from the basic 12 inch by 18 inch by 6 inch block, as required.

SIZES AND PACKING

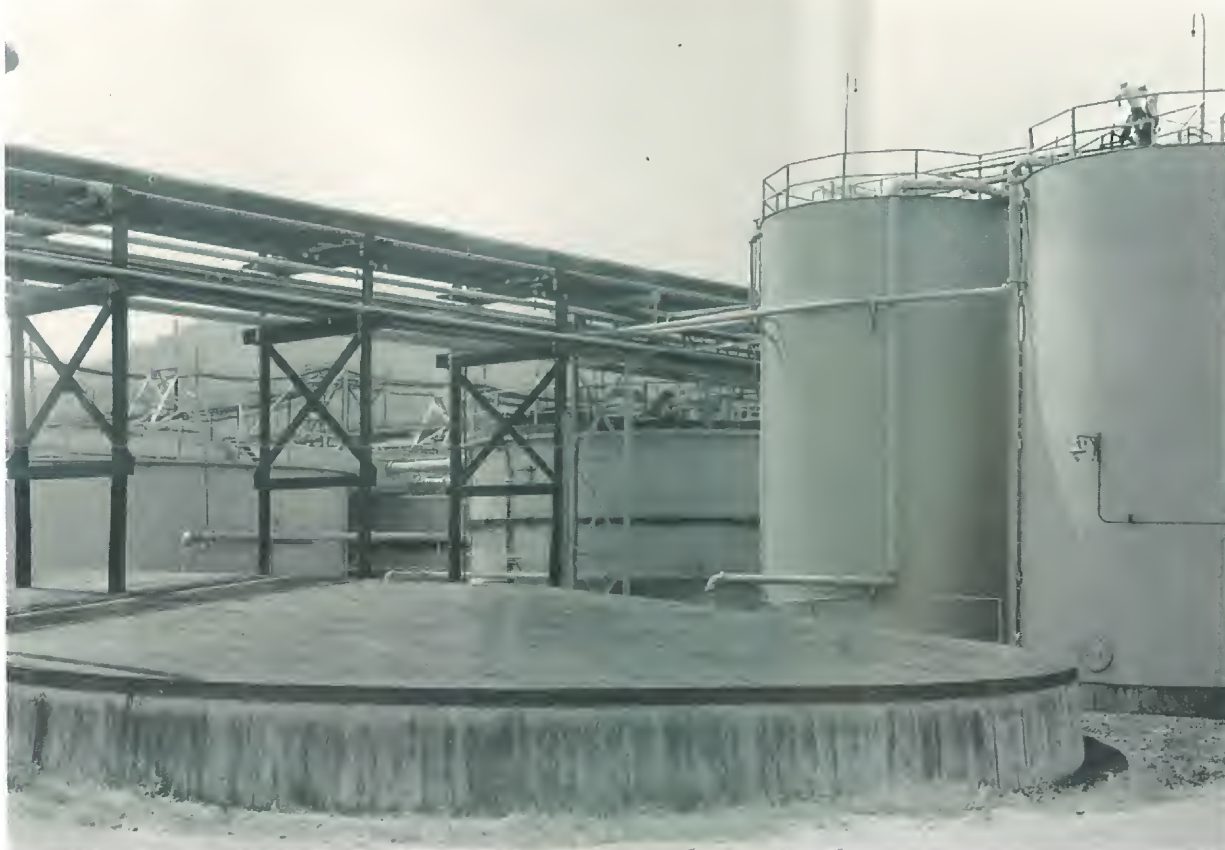
Standard Sizes	Pieces Per Carton	Sq. Ft. Per Carton	Approximate Weight Per Carton
12 x 18 x 2	12	18	40.5 lbs.
12 x 18 x 3	8	12	35.0 lbs.
12 x 18 x 4	6	9	38.5 lbs.
12 x 18 x 4½	6	9	41.0 lbs.
12 x 18 x 6	4	6	33.5 lbs.

PC Foamglas is more rigid and stronger than most materials regularly used for insulation and buoyancy. It will support its own weight in any type of wall construction without danger of crushing or packing. This makes it ideal for building up self-supporting partitions or walls of solid insulating material. It should not, however, be used as a load-bearing wall.

The basic materials and cellular structure of Foamglas give it qualities not possessed by any other insulating material. Its millions of discrete non-intercommunicating, completely sealed cells are absolutely vapor proof and will neither absorb nor transmit moisture. A puncture of the surface or even clear through a block of Foamglas will not result in dissemination of water through the mass. There will be no widespread damage to the Foam-



Roofing with Foamglas insulation is similar to other standard methods.



A neat permanent job of tank insulating.

glas, nor will there be any impairment of its insulation value. It retains its insulation value permanently.

Foamglas, being glass, however little it may resemble the traditional form, will neither absorb nor give off odors of any kind, and is entirely vermin proof. Rodents and other pests will not gnaw through Foamglas nor attempt to build nests in it.

It forms an ideal insulating material because of its rigid structure which prevents packing down or dusting. And yet it may easily be cut and shaped to fit around projections or openings, when necessary, by the use of tools usually available on the job.

Foamglas is absolutely noncombustible. This characteristic is especially valuable where it is used as insulation in flat roofs, over materials

which are not fire resistant, since it affords protection against fire hazards from sources outside the building itself. It may be used as wall insulation in connection with all types of masonry or concrete building construction, in the form of a core wall, with any type tile, block or brick facing. So used, it will help solve many of the problems of temperature control, humidity control and condensation. When properly laid with asphaltic mortar, it forms an effective vapor seal.

PC Foamglas is applicable to many types of floats, life rafts, life boats, industrial floats and other similar uses. It has a specific gravity of 0.17 and is entirely impervious to water. Its weight, as indicated before, is approximately 10 pounds per cubic foot, and is comparable to that of cork or commercial balsa wood. It is an excellent floor insulating material.

E-3

MISSISSIPPI GLASS COMPANY

E-3

Mississippi Glass Products

The Mississippi Glass Company, incorporated in 1876, has its executive offices in St. Louis, Missouri.



A new structural glass with apparent possibilities.

THE company maintains general sales offices at 200 Fifth Avenue, New York City, as well as Chicago, Illinois, and Fullerton, California. The company is the oldest and largest producer of rolled glass in the United States. Its factories are located at Floreffe, Pennsylvania; Fullerton, California; St. Louis, Missouri; and Washington, Pennsylvania. This company produces rolled glass, as distinct from plate glass and window glass, which is largely used in building construction.

Rolled glass figures prominently in industrial and commercial construction work and is applied in a wide field of specialties. It may be described as a rolled glass, one surface of which is imprinted with a pattern to provide decorative effect, translucency, or control of the distribution of light passing through the glass. Rolled glass is produced in a number of different patterns and surfaces and in various thicknesses from $\frac{1}{8}$ inch to $\frac{3}{8}$ inch. It is made in four general types: rolled glass, uncolored; wire glass, a flat rolled glass having a wire mesh embedded within itself for the purpose of providing protection against fire or breakage hazard; cathedral glass, either clear or colored, for the glazing of church windows, leaded work, and lighting fixtures; and heat-absorbing glass, including both the plain and wire glass forms. The diversity of patterns and types makes available a wide variety of utilitarian and architectural light-diffusing effects.

The factory at Floreffe, Pennsylvania, is equipped with one continuous tank having a daily capacity of approximately 160 tons. This plant produces all patterns of rolled glass, both figured and wired, in all standard thicknesses from $\frac{1}{8}$ inch to $\frac{1}{4}$ inch inclusive.

The factory at Fullerton, California, has one continuous tank of about 65 tons capacity per day and one day tank. This plant produces rolled, figured, and wire glass in thicknesses from $\frac{1}{8}$ inch to $\frac{3}{8}$ inch, inclusive.

The St. Louis factory has one continuous tank of approximately 160 tons daily capacity with one experimental tank used primarily for research work. In this plant is concentrated the making of polished wire glass, the production of Coolite Heat-Intercepting Glass, and Structural Corrugated Glass, in addition to the production of the other usual forms of rolled glass.

At Washington, Pennsylvania, the production is limited to various types of cathedral, opalescent and specialty glasses. Here, instead of the conventional continuous melting tank, so-called

day tanks for melting the various colors in individual melts are used.

The products of the company are marketed under the following trade names. In the rolled glass products there are available Artex, Aurora, Bandlite, Bevelite, Dewlite, Factrolite, Florentine, Hammered, Hylite, Luxlite, Pentecor, Pluralite, Prestlite, Ribbed, Structural Corrugated, Structuralite, Syenite, Wired Factrolite, Wired Hammered, Wired Hylite, Wired Pentecor, Wired Ribbed, and Polished Wire. In the Cathedral Glasses the company produces a number of shades of amber, blue, wine, green, white opal, mixed opal, and flint. Cathedral Glass is thinner than regular rolled glass and is manufactured either with one surface hammered, known as Hammered Cathedral, or with both surfaces roll finished, known as Smooth Cathedral, or where additional chemicals have been added to create a seedy effect the glass is known as Antique.

Coolite, Heat-Intercepting Glass, is produced as Hammered or Ribbed Plain, Hammered or Ribbed Wire, and as Polished Coolite.

Three methods of producing rolled glass are employed by the Mississippi Glass Company. The first of these is a continuous rolling method, quite similar to the process used by the Pittsburgh Plate Glass Company at Creighton, Ford City, and Crystal City. The batch is fed continuously to the melting end of a glass tank and flows continuously from the working end between water-cooled rolls to form a ribbon. The pattern is cut or knurled in the surface of the lower roll and is impressed on the lower surface of the glass as the ribbon is formed. The ribbon of rolled glass is approximately 60 inches wide. The glass is carried through an annealing lehr and at the end of the lehr is cut to the desired widths by a continuous cutting device and into the desired lengths by a semi-automatic machine. The selvage edges are stripped off and saved for remelting.

After cutting, the glass moves on a continuous conveyor to be either packed in cases ready for shipment or sent to the open racks to be later used in filling orders. In the production of wire glass by the continuous method, the wire mesh is inserted just before the glass passes between the forming rolls and is incorporated into the sheet as the ribbon is formed.

The Mississippi Glass Company follows the method of placing the wire mesh slightly below the center of the sheet, i.e., nearer the pattern surface than the relatively smooth top surface.



An inferno of glass accepts a core of welded wire to make wire glass. The wire is faintly visible directly under the flame.

This results in a top surface which does not sag in the space between the wire twists, and also improves the ease of cutting. This setting of the wire was adopted after exhaustive tests had demonstrated its desirability.

The second method of producing rolled glass is known as the table method, which is similar in principle to the pot method of plate glass practice. The molten glass is dipped from the melting tank in a manually-operated ladle and poured upon a movable rolling table of steel or cast-iron, which is usually provided with a pattern or figure. The moving table passes beneath a roll or set of rolls to form the glass into a sheet of the required thickness. When formed, the sheet is moved to a transfer table and thence into an annealing lehr. By this method, each sheet is cast and rolled as a separate, individual plate.

A variation of the table process is used in producing wire blanks for polished wire glass. In this process a movable table passes under two forming rolls. The first of these rolls is spaced approximately half the desired thickness of the

finished sheet above the surface of the table; the second, the full thickness of the sheet. The rolls are so spaced that there is room to pour a ladle of glass between them onto the table.

Two ladles of glass are dipped from the melting furnace and the contents of the first ladle poured on the rolling table immediately in front of the first roll, to form the lower half of the finished sheet. As the table moves forward under the first roll, the wire netting is fed onto the top of the first formed half sheet. As the head of the sheet reaches the second roll, the second ladle of glass is poured and the forward movement of the table under the second roll produces a solid sheet of wire glass of the full thickness. At the end of the travel, the finished sheet is transferred into the annealing lehr.

The third process is used in producing cathedral glass and some specialties. The glass is melted in so-called day tanks. These are small melting tanks with a capacity of from one to four tons each which are operated on an intermittent schedule. The tank is heated up to temperature

much as is done in a plate glass pot furnace; the batch is fed into the tank, melted and refined. The finished glass is removed from the tank by ladles. When the tank has been emptied, a new charge of raw batch is supplied and the process repeated. Day tanks operate on a cycle of melting, refining, and production. They are used in the production of cathedral glasses because it is almost impossible to control color if the raw materials are fed to a continuous tank, whereas in the small units the temperature of melting and refining may be so controlled that the desired coloring is properly developed in the finished glass.

The glass is ladled manually from the day tank to a rolling machine very similar to that used in the Bicheroux process except that the machine is very much smaller. The glass is poured into the pinch of the rolls to a moving receiving table below. When the table reaches the end of its travel, the glass is moved to the annealing lehr. In this process the lower roll of the set is figured or patterned to produce the desired configuration on the glass. The sheets produced by this process are much smaller in size and thinner than the other types of rolled glass, the glass being used for church windows, leaded work, and decorative work where strength is not a factor.

Cathedral Glass may be termed a thin rolled glass, usually colored, one surface of which usually has a definite texture by which the vision is partially obscured. The colors in which it is supplied are a number of shades of amber, blue, wine, green, opaque white opal or opalescent, and mixed opal resulting from the mixture of one or more of the shades of colored glass with the opal glass to provide a variegated sheet. A small amount is made in conventional flint or colorless glass. Most of the cathedral is rolled with a flat top surface and a lightly hammered under surface but it is also available in what is known as Smooth Cathedral where flat rolls are used for both surfaces. Where additional chemicals have been added to create a seedy effect in the glass it is known as Antique. In another type, known as Rippled, one surface is ruffled by the roll into shallow irregular corrugations transversely across the sheet.

Rolled glass produced by these several methods is widely varied in form and type, each designed with a definite objective. It is most important, therefore, to select the proper glass to secure the desired effects. While the pattern is applied to the glass to provide obscurity, it is also designed to afford beauty of appearance, as well as directional

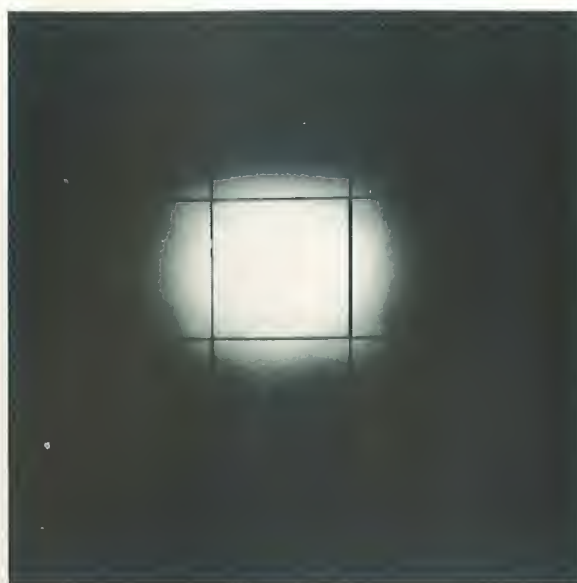
scattering of the light passing through it. With the numerous patterns available, it is possible to provide within a room or building the maximum daylight illumination distributed over the area in the most advantageous manner. It is also possible through the use of certain glasses to soften this illumination and, if desired, to greatly reduce troublesome glare.

Grinding and polishing of rolled glass is done at the St. Louis factory on a grinding and polishing line very similar to that used for the production of plate glass. The blanks are bedded in plaster on flat deck cars which pass under the grinders and polishers in a continuous train. Polished wire glass, Polished Misco Wire Glass, and Polished Figured Glass are produced in a maximum size sheet 60 inch wide by 134 inch long. The accompanying illustrations of some of the types of glass with a representative light distribution chart will show clearly the various types of information available when required. This information will enable the selection of the proper glass to provide the most advantageous directional light distribution to meet particular needs.

COOLITE

Modern industrial construction which provides wide expanses of glass frequently may present a problem of excessive glare and excessive heat from the sun with resultant discomfort in working conditions. The recognition of this fact has led to the development of the Mississippi Glass Company product known as Coolite. This is a low expansion heat-absorbing glass of a pleasing bluish tint which effectively reduces solar light and heat transmission tending to bring both within the comfort range. Numerous tests have shown that installation of this glass may effectively reduce room temperatures as much as 10°. This is a real factor in the comfort conditions of any building in which Coolite is installed. It effectively reduces the cooling load on air conditioning equipment with a resultant saving in operating costs.

It will be remembered that only a portion of the total solar energy passes through the glass. A certain amount is absorbed in the glass itself, a certain amount is reflected, and a certain amount is directly transmitted. A part of the energy absorbed by the glass itself is reradiated from the exterior and interior surfaces of the glass. These quantities vary greatly between clear glass and heat-absorbing Coolite, and the illustrations made from data obtained by the Electrical Testing



Factrolite—a cross-rib pattern which forms tiny concave lenses to break up direct rays and diffuse the light in all directions. The light distribution pattern of Factrolite—the chart is marked off in 1 inch squares to assist in determining the distribution values.

SIMILAR CHARTS ARE AVAILABLE FOR NEARLY ALL MISSISSIPPI GLASS PRODUCTS



Improved Structural Corrugated



Structuralite

Laboratories, Inc. shows graphically what happens to the solar energy in the case of ordinary glass and Coolite and the efficacy of Coolite in excluding heat in comparison with ordinary glass.

The intensity of light in many industrial buildings produces disagreeable glare to such a degree that the use of shades, shutters, or even painting of the windows is resorted to as means of correction. To meet this difficulty, the Mississippi Glass Company has developed a special glare-reducing treatment to reduce the intensity of light passing through the glass. This glare-reducing finish is obtained by producing on both surfaces of the glass a mat finish which scatters the light over a wide area and thereby reduces the spotlight effect. The following table derived from Electrical Testing Laboratories, Inc. reports illustrates the effectiveness of the glare-reducing finish in reducing light and heat transmissions.

COOLITE TRANSMISSION FACTORS

Averages of All Electrical Testing Laboratories
Measurements on Coolite for Last Two Years

Pattern	$\frac{1}{8}$ " Thickness		$\frac{1}{4}$ " Thickness	
	Light	Heat	Light	Heat
Polished (Test Sample)	62%	28%	49%	14.6%
Hammered	59%	26%	47%	12 %
Hammered, G. R.*	43%	21%	31%	7 %
Ribbed	60%	27%	48%	13 %
Ribbed, G. R.*	42%	22%	30%	8 %

*G. R. denotes glare-reducing finish.

Note: The figures for $\frac{1}{8}$ " thickness are for the average thickness of Mississippi $\frac{1}{8}$ " glass of .160 inch.

Glare-reducing finish may also be applied to any of the other Mississippi Rolled Glasses for the purpose of securing uniformity of light by wide diffusion while at the same time subduing the surface brightness of the glass itself.

In addition to the conventional form of flat rolled glass, the Mississippi Glass Company produces Structural Corrugated Glass and Structuralite. Structural Corrugated Glass is made in regular glass and in Coolite. As the name implies, it is rolled in Corrugated form with an average thickness of approximately $\frac{3}{8}$ inch, the corrugations being $2\frac{1}{2}$ inches from crest to crest, and the slope of corrugations being approximately 100°. One surface is lightly stippled to provide the proper degree of obscurity and light diffusion. This glass is especially designed for partitions and decorative work and it can be furnished where desired in glare-reducing finish.

Structuralite is a heavy glass approximately $\frac{3}{4}$ inch thick, especially designed for decorative and

partition work. One surface is lightly stippled for obscuration and light diffusion. The glass is rolled with very shallow cylindrical concave bands from peak to center of valley, giving the effect of a straight line pattern which can be glazed with the lines either vertical or horizontal.

Wire glass, which was originally introduced in the early 1890's as a breakage and fire hazard protection, subject to the rules of the National Board of Fire Underwriters, is made in two types: one of these is made with the conventional hexagonal woven netting and the greater proportion of wire glass sold today is of this type; the second is a comparatively new and improved type of wired glass marketed under the trade name of Misco. In Misco the netting is electrically welded forming a diamond shape mesh, the wires running diagonally in the sheet of glass. This type is available only in Misco Polished Wire, Misco Hammered Wire, and Misco Polished Coolite Wire.

Certain patterns of rolled glass are available, with the flat surface ground and polished, especially for finer architectural work. These glasses are: Aurora, Prestlite, Syenite, Artex, Dewlite, Bevelite, and Bandlite.

VITA GLASS

Ultra-Violet Transmitting Glass

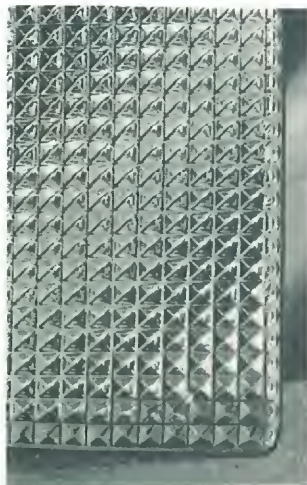
In 1925, Sir Leonard Hill, an eminent British surgeon, was making some comprehensive research into the value of natural sunlight and daylight for human health and well-being. He recognized that the actinic, or health, part of natural light lay principally in the short ultra-violet rays between 2900 and 3200 Angstrom units wave length. He discovered that these short ultra-violet rays do not penetrate ordinary window glass and he pointed this out to F. E. Lamplough, a Fellow of Trinity College, Cambridge, and a scientist with experience in the glass field.

After considerable research and experimentation, Professor Lamplough invented Vita Glass which transmits a large portion of the beneficial ultra-violet rays of natural light.

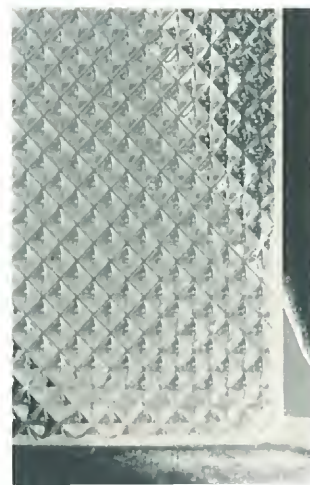
In 1926 the Vita Glass Corporation was formed and acquired the sales and manufacturing rights of Vita Glass for the United States and Canada, and it has been in operation since that time, becoming connected with the Mississippi Glass Company for manufacture and sales promotion in 1933. The Vita Glass Corporation is the pioneer and only maker of ultra-violet glass in this country.



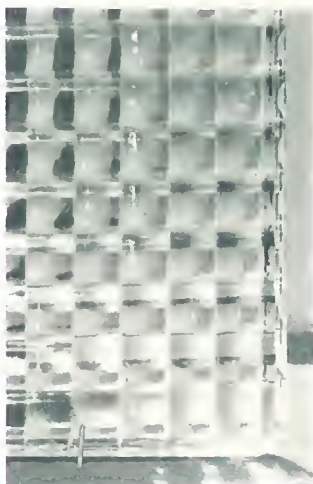
Magnalite "A"



Prestlite



Aurora



Magnalite "B"



Hammered



Misco



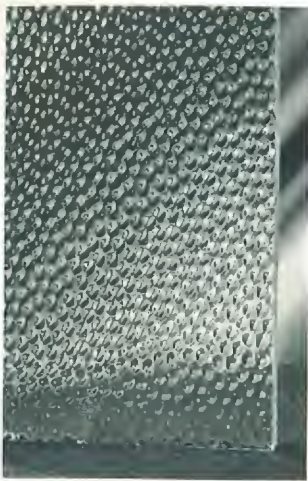
Hylight



Pluralite



Ribbed



Dewlight



Artex



Syenite



Florentine



Bandlite

SOFTONE FINISH

Softone finish is a process, or surface treatment, that may be applied to one or both surfaces of the glass. It gives the glass a mellow, satinlike finish. It transforms a semi-transparent, non-diffusing glass into a glass that is quite obscure with excellent light diffusion, thus giving a high general level of illumination—a light that is soft and restful and, at the same time, affording complete privacy.

Softone finish is more expensive than sandblasting or acid etching. Applied on one surface, it reduces light transusion approximately 3%. Applied on both sides, it reduces light transmission about 16%.

Softone finish is supplied on Bandlite and Bevelite only.

Sheet Vita Glass was first manufactured in this country in 1931. It was made by the Fourcault flat drawing process in a single machine unit built by Vita Glass Corporation at the plant of the Flat Glass Specialty Company at Clarksburg, West Virginia. The glass has a final, permanent ultra-violet transmission of 40 to 50 per cent of the health-giving ultra-violet rays in natural sunlight. Vita Glass of similar effectiveness has since been manufactured in the rolled and wire types by the Mississippi Glass Company at Washington, Pennsylvania.

Controlled tests on animals and chickens conducted by a number of competent doctors and scientists, both in this country and in England, prove not only the permanence of ultra-violet transmission of Vita Glass, after a short period of solarization, but also the effectiveness of the

natural light coming through it for the prevention of rickets. The results of these tests are backed up by the general experience of many users of Vita Glass in this country. The greater germicidal quality of the light through Vita Glass has also been proved by tests made at Teachers College, Columbia, New York, N. Y.

One can get a healthy coat of tan from the light coming through Vita Glass which is not possible with ordinary window glass.

Vita Glass, which costs somewhat more than ordinary glass due to the special ingredients which go into it and the special process of manufacture, is supplied in approximately 21 oz. sheet glass, $\frac{1}{8}$, $\frac{3}{16}$, $\frac{1}{4}$ inch rolled, and $\frac{1}{4}$ inch hexagonal mesh wire Vita Glass (not polished). $\frac{5}{32}$ inch plate Vita Glass is also furnished, made by Pilkington Brothers, England, and imported as occasions permit.

E-4

PRESSED PRISM PLATE GLASS COMPANY

Pressed Prism Plate Glass Company

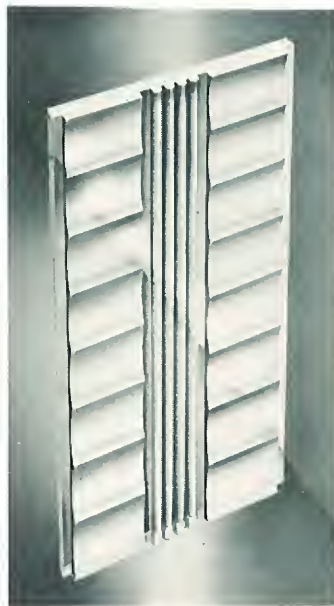
The Pressed Prism Plate Glass Company whose general office and factory is located at Morgantown, West Virginia, produces Imperial Ornamental Plate Glass, Imperial Architectural Glass and Imperial Sculptured Glass. It operates one continuous and one semi-continuous tank furnace.



Architectural glass—straight and curved and sculptured panels give this office a glass personality. The desk, too, is of glass.



310



304



309



300



301



305

IMPERIAL Ornamental Plate Glass may be distinguished from other figured glass by the uniformity of pattern and the absence of disfiguring waves or roller marks. The figured design is die-pressed into the glass, and the unfigured surface is ground and polished.

The process of die-pressing the design insures a clear, sharp, even figured pattern which is not obtainable by other methods. These qualities are generally recognized as essential in good architectural and practical lighting installations. A

large selection of patterns permits a choice of line and directional effect which will aid the architectural and decorative motif. Horizontal or vertical accents may be made to continue through light openings without break.

The prismatic nature of the die-impressed translucent surface affords maximum diffusion of light while at the same time obstructing clear vision.

Imperial Ornamental Plate Glass is unexcelled for corridor and vestibule doors, bank or office partitions, transoms, illuminated ceilings in banks,

railroad stations, hospitals and apartments. It is also used in glazing cabinet doors, vending machines, private offices, etc.

It is available in all patterns in $\frac{1}{4}$ inch thickness and maximum dimensions up to 72 inches by 84 inches. Thicknesses other than $\frac{1}{4}$ inch may be obtained on special order. It may be laminated by the usual laminated glass processes. It is impossible to temper this product.

IMPERIAL ARCHITECTURAL GLASS

Architectural Glass and Sculptured Glass were originally developed by the Corning Glass Works and many original Corning stock shapes have been used in a number of architecturally fine and interesting buildings throughout the country.

Manufacture of these products has been transferred from the Corning Glass Works to the Pressed Prism Plate Glass Company, since it was found that the latter organization could produce this special type of material more economically.

Imperial Architectural Glass is a molded product. Relatively a new material, its possibilities are largely unexplored, although it represents a high degree of artistic and technological excellence and much fine work has been produced. A variety of individually styled shapes are carried in stock for immediate shipment. Special shapes can be made up to meet a designer's specifications if necessary, although it is often possible to fabricate stock shapes to meet odd conditions. The molded



By day or by night, this doorway creates a favorable impression by the use of modern glass.



303



308



302



Breathless beauty for a modern fireplace. This entire mantel is of glass. Sandblasted flowers background a lovely crystal Madonna. Architectural glass frames the mantel and illuminates the exquisite decoration.

figure or pattern of the glass is sharp, even, and clear. It is a cast molded product in which small bubbles which do not in any way affect the beauty of the panel may appear within the ware itself.

Imperial Architectural Glass is furnished in a clear, water-white glass especially designed to meet the rigors of architectural decorative lighting work. The molded surfaces are fire polished as a result of intimate contact with a smooth mold and at times may be quite wavy. The back or flat surface may be ground and polished with a plate glass finish or if desired, may be supplied with a softly matted, sandblasted surface. The ground and polished surface may be silvered if desired.

Abutting ends are usually ground where the appearance of the joint is of minor importance. The ends should be polished where it is desirable to minimize the evidence of a joint. Edges are generally furnished wheel-cut. Edges abutting or joining another material, without a covering frame, or which will be exposed, should be ground or polished. Imperial Architectural Glass is used for decorative strip illumination, illuminated bulkheads, friezes, spandrels, door and fire-place trim, band courses, decorative inserts, pilas-



The mold delivers overlapped sections.



A close-up of the mold pictured above. Showing the depth of detail possible.



The sculptor prepares a bas-relief as for straight casting in metal.



Here is a picture of an interrupting architectural detail wrought in sculptured glass — the frostlike appearance creates a new effect.



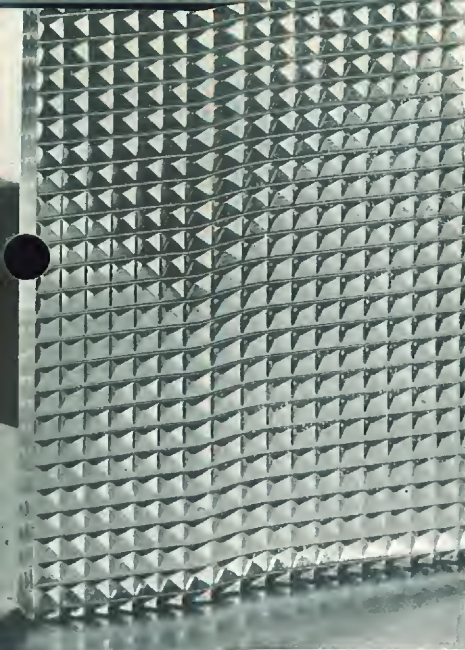
Frozen in glass, these figures decorate a modern building entrance.

ters, interior screens, partitions, phonograph cabinets and back bars. Because of its thickness, the glass is very strong and may be used full size in all positions. Additional safety may be secured by supporting all 4 edges, especially if the panel is horizontally installed.

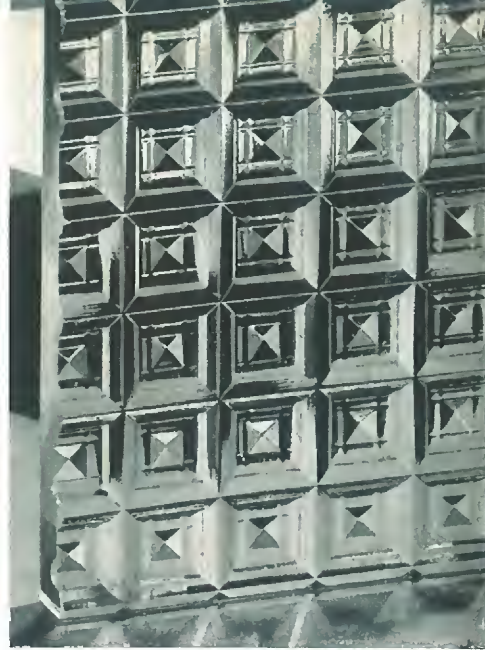
IMPERIAL SCULPTURED GLASS

The development of Sculptured Glass closely parallels that of Architectural Glass. The 2 materials have grown hand in hand.

Imperial Sculptured Glass is truly a result of the craftsmanship and artistry of the sculptor, working in bas-relief or intaglio. It is a faithful, permanent sculptural treatment which has the sparkle and life of transparent glass, and it is possible to so design a panel that it may be seen and its beauty appreciated from both sides. Each piece must be cast in a mold which has itself been made from castings obtained directly from the artist's original clay. The process of making molds from castings of the sculptor's original work guarantees the retention of all the characteristics of the origi-



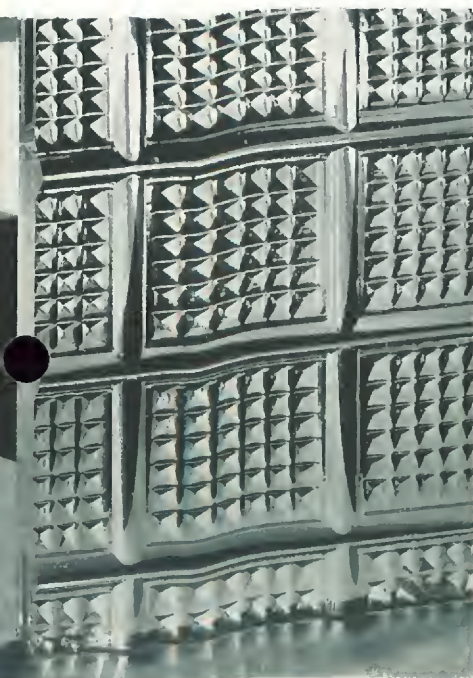
0-1



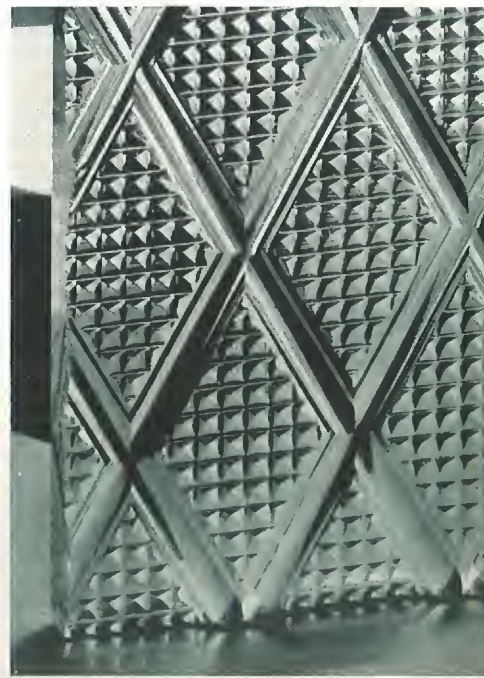
0-2



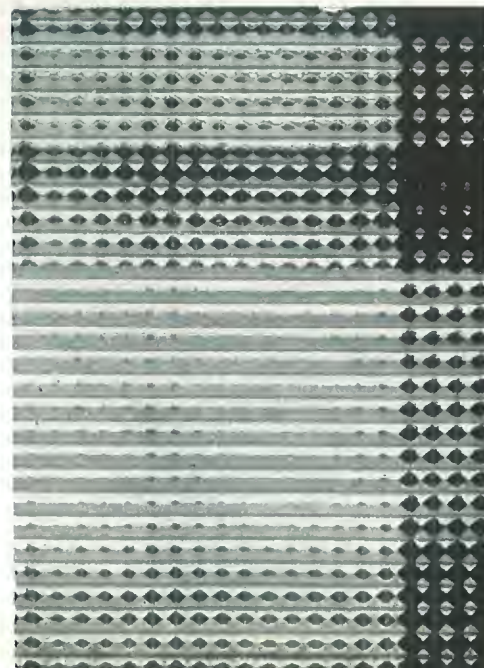
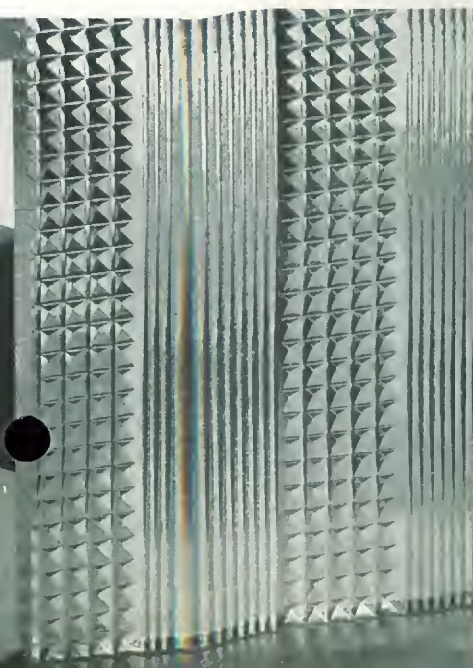
0-3



0-4



0-5



IMPERIAL ORNAMENTAL PLATE GLASS PATTERNS

On this page are shown the seven patterns in which Imperial Ornamental Plate Glass may be obtained. They are known as 0-1, 0-2, etc., up to 0-7 prism glasses.

On page 4 are shown six of the Pressed Prism Plate Glass Company architectural glass patterns. Three more will be found at the bottom of page 5 and the remaining two will be found at the bottom of page 10.

All of the designs of the 300 line of Pressed Prism Plate Glass Company architectural glasses are shown in line details in Section J-13.

Far left, 0-6

0-7

nal clay including marks of the sculptor's tools and any texture which he may apply. These molds are of a proprietary nature and there are no stock shapes of Sculptured Glass.

A vital part of the beauty of Sculptured Glass lies in the constant change and filtration of light through the varying thicknesses of glass. This quality and the transparency of the panels has made them much in demand by architects for use as transom decorations over the entrances of large buildings.

It is possible to produce many striking effects by control of surface texture as well as by change of contour. A slightly rougher texture where shadows are desired will be quite as effective as an actual variation in thickness. The original sculptured surface resulting from intimate contact with the mold may be left fire polished. However, a change of surface texture may produce almost as many striking effects as changes of actual contour details.

The back of the Sculptured Glass panel may be left with grains of sand adhering just as it comes from the casting operation. This sand produces a translucence which the glass would not otherwise have, and creates an impression of great glass

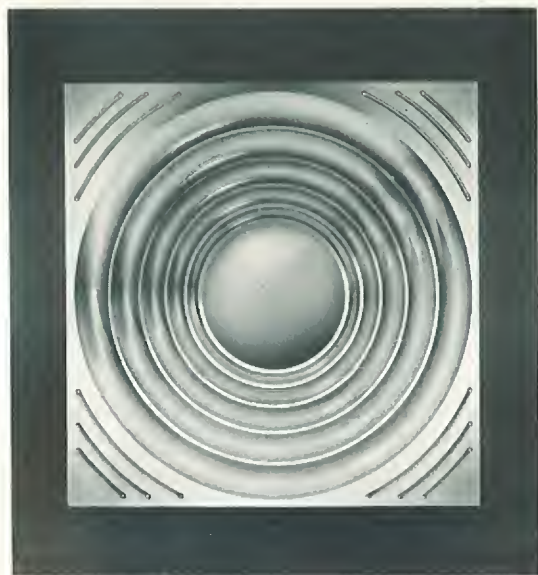
thickness and depth value in the design.

Where the depth of relief is not great, it is possible to grind and polish the back or flat surface. This should be done when the glass is to be viewed from both sides.

The glass metal used for Imperial Sculptured Glass is generally a subtle transparent sea-water green which has been found to be most pleasing and harmonious in architectural work. Other types of glass are available by special arrangement.

Imperial Sculptured Glass may be prepared in single panels as large as 4 feet square, reproducing a single design, or large combination panels may be made up from a number of sections. It is suggested that the designer limit the "section through the glass" to a minimum of $\frac{3}{8}$ inch and a maximum of $1\frac{1}{4}$ inch and that at least a 5° draft be provided on all contours to permit proper casting.

Panels sculptured with the designer's own decorative creations are especially suitable for use in large ornamental windows, interior screens, transoms, spandrels, and indirectly-lighted murals. Mounting details may readily be adapted to any type of opening or any kind of building construction, although it is necessary for the manufacturer to furnish detailed instructions for each installation.



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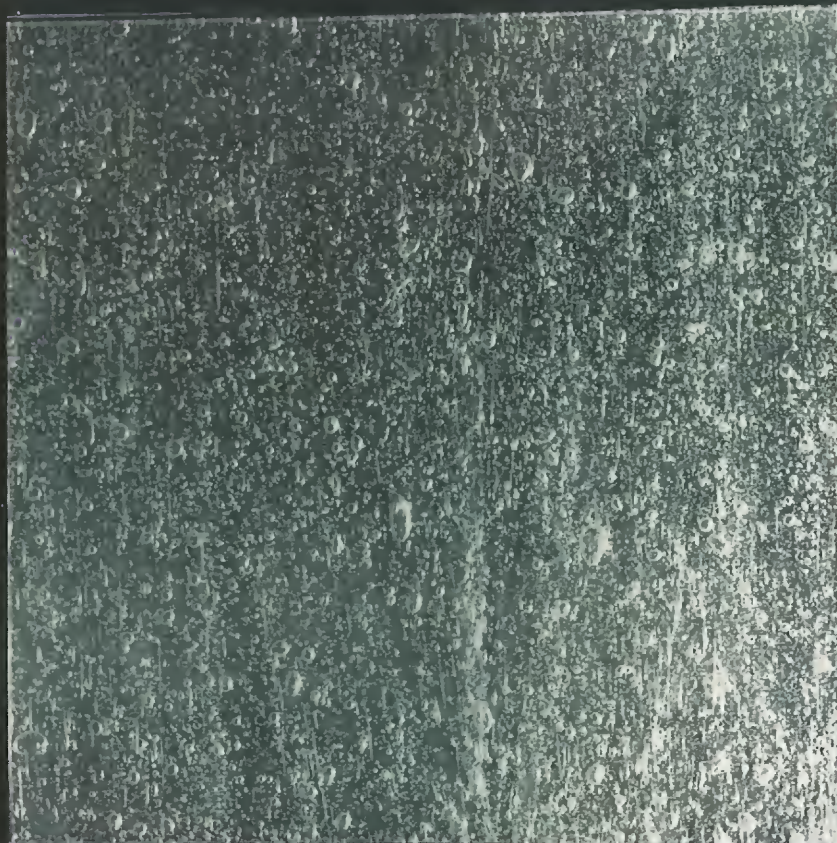
307

E-5

LEADED GLASS

Leaded Glass

The cathedral window was the first use of this glass. Nothing has displaced glass for this use.



A light of seeded Cathedral glass, actual size. The seed defect and scatter light producing the translucent effect.

THE term Leaded Glass generally suggests the rich stained glass compositions of highly artistic cathedral windows that have commanded world-wide admiration since medieval times.

The development of Gothic architecture in the mid-twelfth century period greatly increased the size of windows, made stained glass the important color factor in the decoration of churches and to a great extent displaced fresco painting.

The rare beauty of medieval leaded glass windows seems to have become a lost art and has never been equaled in modern production although much imitated. Like the art of the old masters, the stained leaded glass windows in the notable cathedrals of earlier centuries are treasured and admired for their unsurpassed richness of color and design.

The making of leaded glass windows is a special vocation unto itself, embracing all manner of design and detail from the simplest pattern to the portrayal of the most intricate artistry in subject and color. The panel may be composed of many cut pieces of irregular shape, each having its own framing of metal to form the whole design, in lines against a luminous background. Leaded

glass actually covers a method of treatment rather than a particular glass product.

In leaded windows, the glass employed may be clear or of selected solid colors to interpret the artist's presentation, or the glass pieces may be tinted and fired to portray the theme of design. The glass to be used is cut up into pieces fashioned to the design and secured into the metal cames. These cames are usually H sections of metal which have been spread to receive the glass, and can be fully assembled to the design before the glass is set. When the glass is in place, the open legs of the section are pressed tight against the glass and the joints secured usually by soldering.

Zinc and copper are sometimes used instead of lead in the construction of so-called leaded glass windows, especially where the strength of the installation is of importance. Large leaded glass panels are provided with steel stiffening rods or bars for rigid installation.

The use of leaded glass for windows of modern buildings was at high tide some years ago and has since greatly diminished as new, attractive and more acceptable glass types supplanted the outmoded patterns.

E-6

OTHER FLAT GLASSES

Other Flat Glasses

Prism, Ribbed, Antique, Cased, Flashed, etc.



Pentecor, Ribbed Glass, actual size.

A NUMBER of so-called specialties produced by other manufacturers find an outlet through the widespread warehouse distribution facilities of the Pittsburgh Plate Glass Company. Some of these products are clear, transparent glass; some are translucent. In some cases, the surfaces are highly configured while the main body remains essentially flat, and in others, the whole body of the glass is corrugated.

PRISM GLASS has been, to a degree, described under the Mississippi Products and some special types of prism glass are shown in the section on the Pressed Prism Plate Glass Company. The prism surface may consist either of raised projections from the general plane or may be indentations below that plane. The purpose of prism glass is to permit maximum transmission and wide scattering of visible light, while distinctly interfering with clarity of vision and, in effect, producing translucency. Prism glass is always either a rolled or pressed product.

RIBBED GLASS is a rolled or pressed product, one surface of which is configured with continuous parallel prismatic projections extending above the main body of the glass. The surfaces of the ribs are smooth and flat. The angle at which the faces meet determines the light directional properties of the glass.

ANTIQUE GLASS is essentially a sheet glass product throughout which small bubbles or seed are widely disseminated. One type of antique glass is produced by the Mississippi Glass Company as a rolled glass product. In many instances, the surfaces of the antique glass are more or less roughened in the process of manufacture. They show many short, essentially parallel surface marks, and the included bubbles are frequently very much elongated in the direction of rolling.

CATHEDRAL GLASS is a generic term for a number of patterns. The Cathedral glasses are fully described in Section E-3 on pages 4 and 6. It is usually approximately $\frac{1}{8}$ inch thick.

FLUTED GLASS is essentially a rolled product in which usually only one surface is configured. The flutes may be somewhat round in character or may come to sharp apices. Usually the flute is a smooth, wide pitch, curved depression between sharp peaks. Sometimes, however, the sides of the flutes are plane and meet with a sharp line both at the bottom of the depression and the top of the peak and, except for the width of the pitch, might be termed ribbed.

REEDED GLASS is the direct opposite of

fluted glass. The apices are narrow pitch, smooth curves, while the depressions are usually sharp lines where the curved surfaces meet.

Fluted glass and reeded glass may be produced either by rolling, pressing, or by being blown into molds. In the latter instance, the glass is usually blown or pressed into rectangular molds and the fluted or reeded faces cut apart at the corners of the mold.

RIPPLED GLASS is a rolled product in which one surface shows small waves or ripples, as the name implies.

POT COLORED GLASS is a term descriptive of any homogeneous glass of uniform color. The term applies only to the uniformity of color of the glass metal and is used to distinguish solid colored glasses from flashed or cased glasses.

CASED GLASS is a term used to describe a glass product consisting of 2 or more layers of differently colored or different composition glasses fusing into each other in the process of manufacture as distinguished from ceramic enameled glasses which are produced by fusing a secondary glass surface upon an already finished piece of glass. Cased glasses are hand-blown products. The individual types of glass are melted in separate pots in a pot furnace. Usually, the pots used are covered pots. The workman gathers a gob of clear glass on his blowpipe and, when he has gathered a sufficient quantity, glass of a different color is gathered from an adjacent pot to enclose completely the original gob in a reasonably heavy layer of the new color. Then the glass is blown into a cylinder and flattened by the typical hand-made window glass process. The two glasses are uniformly thick over the entire area of the sheet, although the base glass is likely to be materially thicker than the encasing glass. Frequently, cased glasses are produced by making a gather of the desired color, then a gather of clear glass, and then, a second gather of the initial color and blown as before. This produces a sandwich in which the surfaces are colored while the core or main body of the glass is clear. Sometimes, cased glass is known as flashed glass, in the flat glass trade.

FLASHED GLASS is a glass in which the color has been produced by subjecting the finished article to a reheating process which develops a color latent in the glass. The use of the term in the flat glass industry as applied to cased glass, is erroneous, although almost universal. Very little actual flashed glass ever comes into the flat glass market. The term applies properly only to various

types of tableware and other decorative glass products. There are several kinds of lighting glassware which are truly flashed glass in which the main bowl of the glass is opalescent, while the throat and shoulders are clear.

Opal glasses are translucent products which may be pot-colored or variegated. The translucency is produced by incorporating in the glass melt one or another of several different opacifiers which develop the opalescence upon cooling or, as just noted under Flashed Glass, upon reheating. Fire opal designates a glass in which the opalescence is insufficient to obscure the actual outline of a light source held a short distance behind it. Opalescent glasses are truly light diffusing glasses

as distinguished from sandblasted or configured surfaces which merely scatter the light. The distinction is that no light passes directly through an opal glass, while considerable portions of light will pass directly through a configured or sandblasted surface and will be refracted over a rather narrow angle from the roughened surface. In an opal glass, the light is reflected from one opalescent particle to another within the body of the glass, so that the light emerges from the second surface as though originating from a multiplicity of small particles in the glass body, each of which has become essentially a miniature light source whereby the light is widely diffused in an angle of almost 180 degrees.

SECTION "F"

FABRICATION

F - 1

SURFACE TREATMENTS

F - 2

EDGE FINISHING

F - 3

HERCULITE FABRICATION

F-1

SURFACE TREATMENTS

Surface Treatments

To further the inherent qualities of glass and to heighten its beauty and usefulness, many processes are employed. The processes described are standard.



A crew of expert workmen spot polish a large plate on the scratch wheel. The man at the left is the operator.



The artistry of Nature produced this example of single chipped glass.

CHIPPING

CHIPPED glass dates back among the earlier types of decorated glasses and still remains popular on account of its unique attractive appearance and versatile applications. The brilliant surface

pattern produces an obscure or semi-transparent, translucent glass.

SINGLE PROCESS CHIPPING

The glass is first blasted with fine sand under



Hewing to the line in double process chipping offers many possibilities for interesting decorative effects.

air pressure, which roughens the exposed surface. The roughened sandblasted surface is coated with a special glue. When dry, the glass is placed in a hot-room, oven or kiln and subjected to heat. The glue peels or curls off in flakes, tearing off slivers of the glass in various forms, each flake leaving

its imprint mold in the clear glass in a delicate tracery pattern. Since no 2 flakes are alike, the detail is nonrepetitive, yet the general appearance of the pattern is uniform. The actual size photograph above shows how cleanly chipping can be done up to a line.



Opal glass cased onto a clear glass base has been sandblasted away to produce this design.

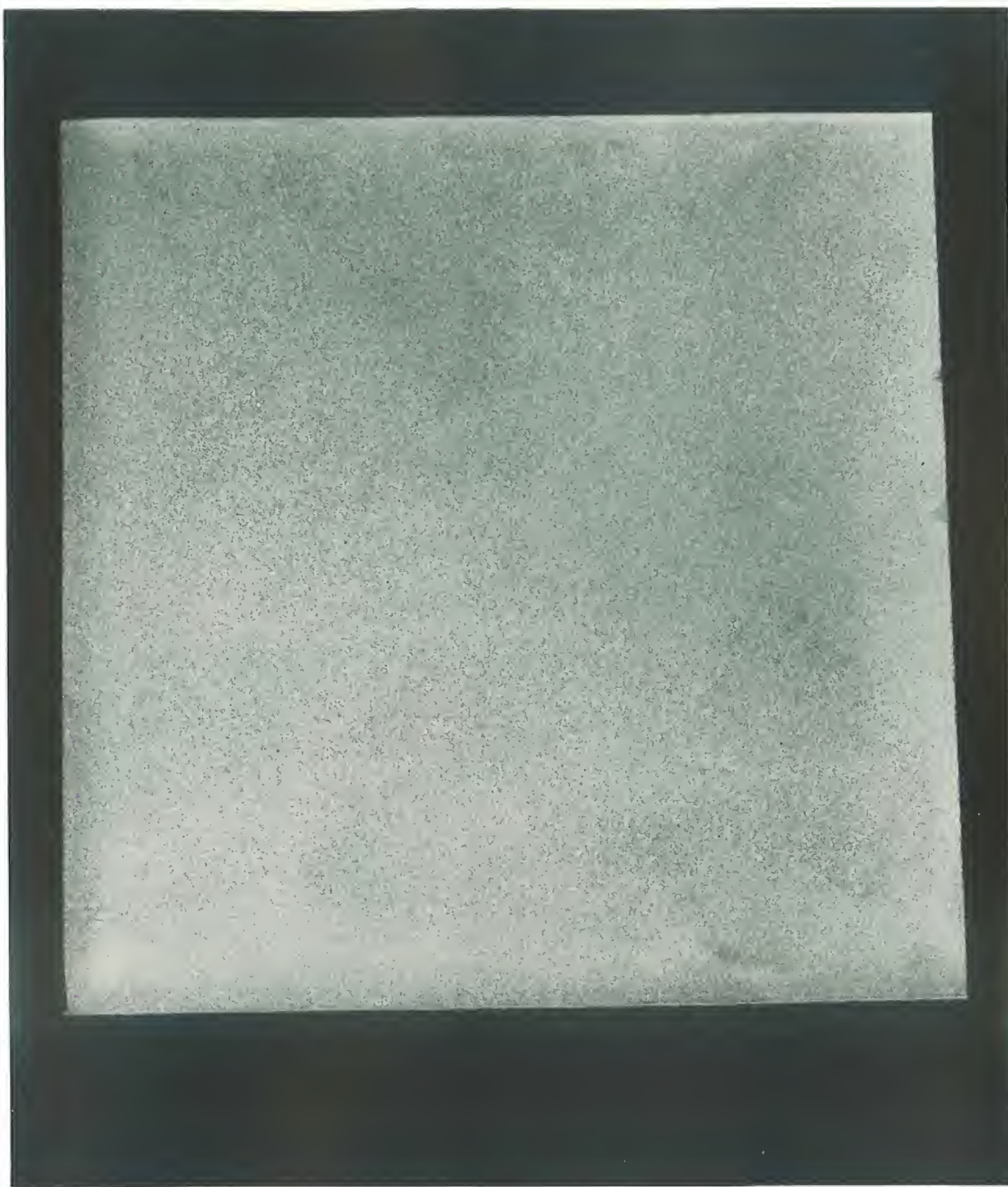
DOUBLE PROCESS CHIPPING

Ordinary single process chipped glass is re-coated with glue and subjected to the same treatment as described for single process chipping. The second flaking-off of the glue removes all remain-

ing traces of the original sandblast, producing an all-over pattern of intricate design.

Double process chipped polished plate glass is especially rich and brilliant.

Chipped glass is available in window glass, plate glass or rolled rough glass—either single



This matt surface is the result of sandblasting preparatory to chipping—or for its own sake.

process or double process as may be desired.

Special designs in chipping, such as clear margin or decorative patterns, clear letters, etc., are produced by protective masking of the glass in the desired clear space before the sandblast process or glue application.

ETCHING

Similar to the engraving process, wheel-cut etching is done by cutting into the surface of the glass on a thin upright grinding wheel of small diameter. The desired design is marked on the



Wheel cut engraving or etching may yield many patterns, with a wealth of detail in shading and line.

glass and the pattern cut accordingly, producing engraved satin finish work, which can be polished if desired. (See Acid Etching.) Beautiful graceful designs can be executed according to the individual skill of the operator.

ENGRAVING

A surface operation with narrow face, power-driven grinding wheels, usually followed by polishing (see Etching). The photograph above shows an actual size floret.



Otherwise invisible, the edge lighting of this deep sandblasted $\frac{3}{4}$ inch glass springs out from the numerals.

ACID ETCHING

By the use of hydrofluoric acid, or one of its compounds, such as white acid, consisting of hydrofluoric acid, carbonate of soda and water, glass surfaces may be given a frosted appearance

or a semi-polished appearance in various degrees.

To obtain acid etched designs upon the glass, the surface is masked with paraffin or tin foil. The design is traced on the paraffin or tin foil and cut away to leave the bare glass exposed. Acid solution is poured on the glass lying flat. After the acid



The contrasts in this design are obtained by varying pressures and duration of fine sandblast.

has properly etched into the glass, it is poured off, and the glass thoroughly washed with cold water and the paraffin or tin foil removed.

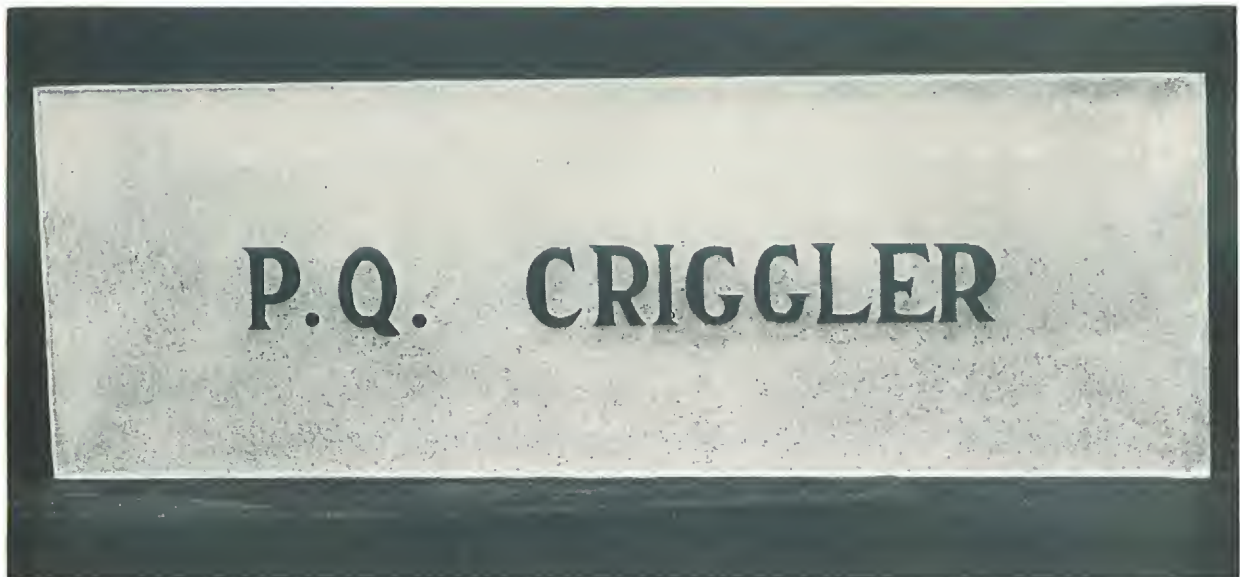
Hydrofluoric acid is very corrosive and should be used with extreme caution.

ACID STIPLING

The foregoing process describing Acid Etching is used. When the acid is on the glass it is sprinkled with small shot or coarse sand, which causes a stipple dotted etched effect.



Deep detail sandblasted into a 1 inch thick plate. The edges beneath have been rabbetted about $\frac{3}{4}$ inch on a grinding wheel.



A true cameo effect results from blasting away the ruby of a cased ruby glass.



The arm blocker in the mirror shop is a most useful tool.

GRINDING

The process of mechanical surface grinding is described in the section of the Manual devoted to the manufacture of plate glass, and should not be confused with sandblast methods described elsewhere.

HONE FINISH (See Mud Ground)

The surface finish of any ground glass varies in smoothness according to the coarseness of grain of the abrasive used—the finer the grain the smoother the finish.

In producing hone finish, the finest grades of sand or emery are used.

Another method of producing a surface similar to hone finish is by blasting with fine carborun-

dum and treating the surface with a special solution of hydrofluoric acid.

MUD GROUND (See Hone Finish)

Mud ground finish resembles a hone surface produced by using the finest grades of sand or emery as the abrasive.

The terms hone finish and mud ground are synonymous. Hone finish usually applies to Carrara Glass; mud ground usually applies to plate glass.

SUEDE FINISH

By carefully controlling the polishing process just short of finishing the glass to a brilliant high luster, the less reflective suede finish is obtained.

Suede finish presents a surface with soft reflections and rich depth of color without glare. Suede finish is resistant to absorption and readily cleaned, and is therefore popular in Carrara Glass for store fronts.

SURFACE MITERING

Mitering is done either by the processes described under etching and engraving, or on special precision mitering machines. It is usually in the form of a V-shaped groove cut into the glass in straight lines. Polished V miter lines are especially attractive for plate glass door panels or decorative mirrors.

The Ribbon miter consists of a series of small miter lines spaced about $\frac{1}{16}$ inch to $\frac{1}{8}$ inch apart, to appear as a band or ribbon of any desired width. Ribbon miter pattern is produced in satin finish only.

SANDBLASTING

A sandblast surface is obtained by blowing a granular abrasive such as sand or carborundum in a stream of compressed air or steam against the glass. The product has a milky, frosted appearance and is commonly known to the trade as ground glass (not to be confused with mechanically ground glass—described under Grinding).

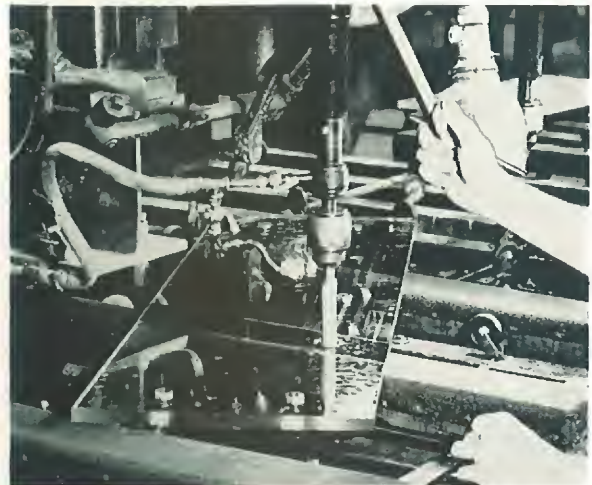
Coarse sand produces a rough ground surface, while fine sandblast produces a smoother shallow tone. For superfine smoothness, fine carborundum is used.

To obtain sandblast designs, a resist cover is sealed to the surface and the detail of the design is cut out, leaving the bare glass subject to the sandblast attack. The resist or stencil may consist of a water-soluble, gelatinous resin, rubber, or heavy adhesive paper or other similar material which is easily removed when the work is finished.

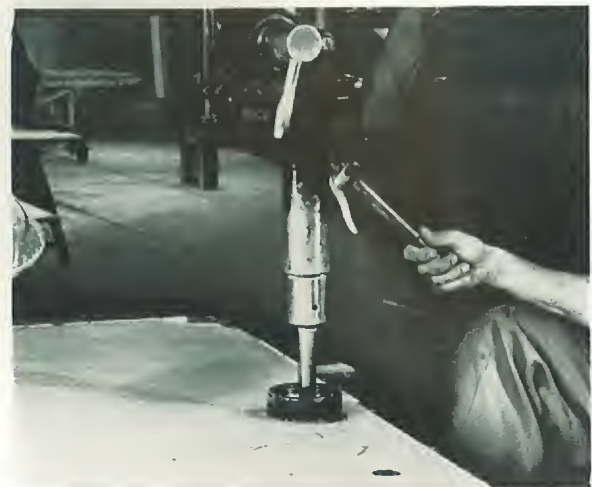
In this manner decorative figures, signs and displays, trade-marks, store names, etc., are sandblasted on facia panels and beautified by the application of gold leaf, bronze, lacquer or enamel in colors desired. This is a popular treatment of sign panels on Carrara store fronts.

Shading of tones or degrees of density in sandblast design or all-over variation is accomplished by successive removal of different portions of the resist, the finest sandblasting being done last. Fluted or column effects are thus produced.

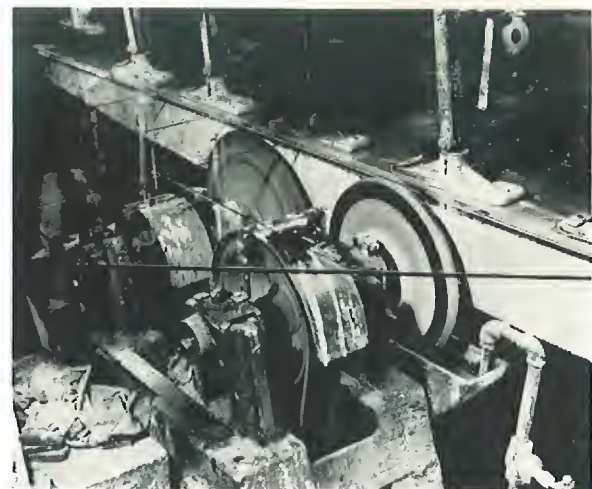
So-called Carved glass is generally produced by deep blasting.



Glass may be drilled with a broken triangular file and loose abrasive.



A better job is done with a carboloy drill, in a bath of abrasive.



Machine-mitering a design into the face of a large plate.

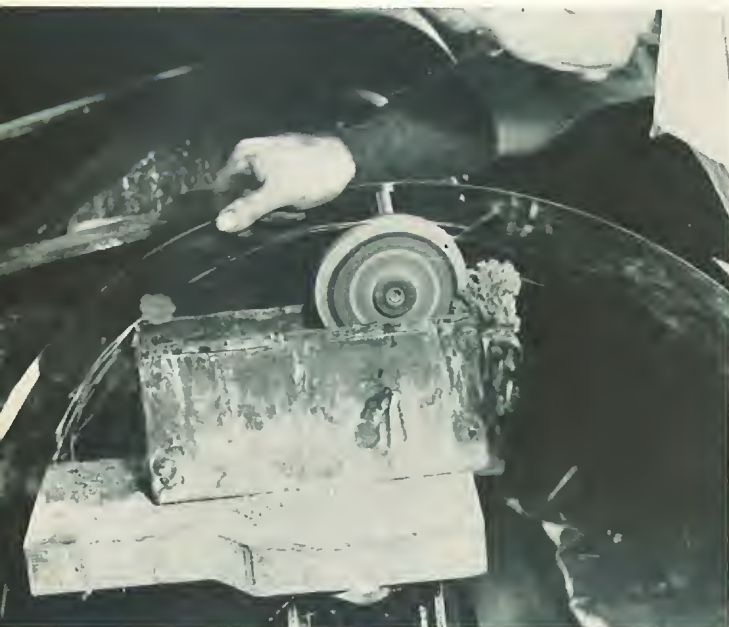
Large holes or irregular cut-outs may be cut out of glass plates by the blasting operation. (See Sandaire.)

GROUND GLASS

(See Sandblasting.)

CARVED GLASS

By deep blast with carborundum instead of sand, Carved glass designs are produced on heavy glass, by the process described under Sandaire.



Etching or engraving a circular design by a hand controlled operation.



Carving out the letters for a laminated sign.

For figure work or bas-relief, several depths of cutting produce shadows and high lights which bring out the beauty of the glass and the detail of the design.

The deep cutting is accomplished by a series of blasting operations on the glass and alternate removal of certain parts of the masking tape or resist, to obtain various depths of carving.

A beautiful effect on carved plate glass is obtained by treating the carved portion of the panel with a solution of hydrofluoric acid.

(See Sculptured Glass—Cast Panels—Architectural Glass, Section E.)

SANDAIRE

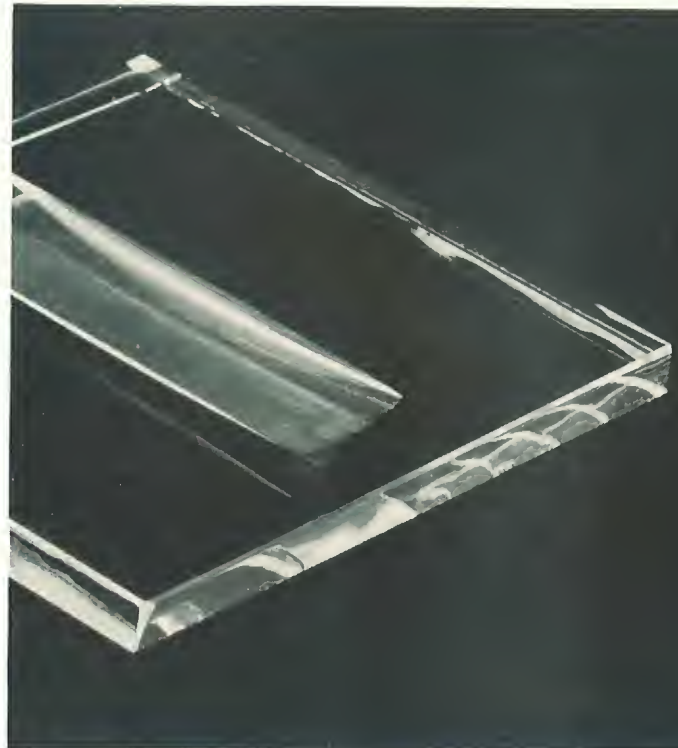
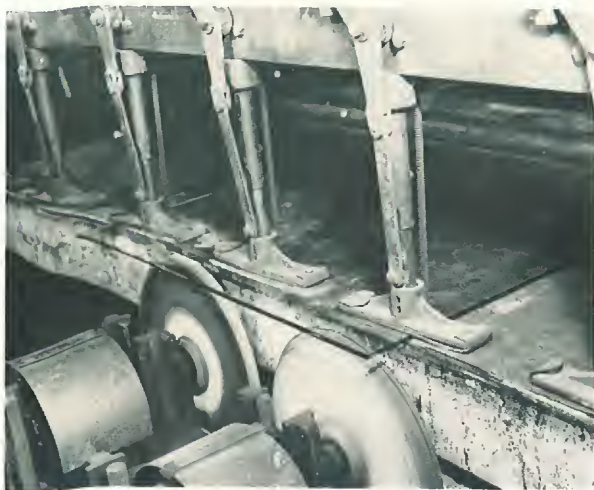
Sandaire is the term applied to a process developed by Pittsburgh Plate Glass Company which makes possible the fabrication of intricate glass shapes and flat glass cut designs in one complete unit.

Bas-reliefs, shallow or deep etched, decorative glass shapes, design panels in infinite variety, illus-

Laying out the resist design on white Carrara for the sandblast.

A polished finger pull in a small piece of clean-cut $\frac{1}{4}$ inch plate glass, with seamed edges.

The finger pull notch takes shape in a large panel.



trative figures, script letters, delicate medallions are but a few of the decorative possibilities of the Sandaire process.

Sandaire designs, figures and letters or silhouettes are particularly adapted to the embellishment of display advertising on store fronts. The Sandaire units, usually in contrasting colors to their background, are laminated to the face of

the store front. The wide variety of Carrara Glass colors offers many combinations for Sandaire applications to Carrara store fronts.

The process of fabrication of Sandaire units is by blasting technique.

The entire surface of the glass is covered with heavy adhesive masking tape. A tracing of the figure or letters to be produced is placed on the



From left to right—Suede, Sandblasted, and Hone Finished Carrara Glass.

masking tape and the lines of design cut through. The sections of tape on the parts to be blasted are removed while the remaining tape protects that space from the blast. The exposed glass is cut away by the sandblast.

If Sandaire work is to be laminated, a special cement to withstand the elements is applied to the back of the Sandaire unit and attached to the background.

ITALIAN PROCESSING

Italian processing consists of the application of transparent colored paints or lacquers to retouch designs or patterns blasted, etched or engraved into glass surfaces, especially Tapestry Glass or polished plate glass.

Colorfuse Italian processing—A very brilliant panel made by attaching a mirror to the design painted side of the Italian process glass. The 2 glasses are sealed with tape and bound together.

FINGER PULLS

To facilitate opening or closing of sliding doors in all glass showcases, finger pulls are provided.

Finger pulls or grooves are made by pressing the glass against small, narrow-faced grinding wheels which cut the notch to the desired shape and depth. Usually the groove is subsequently highly polished.

Finger pulls consisting of small glass shapes may also be laminated or cemented on glass panels, if preferred.

F-2

EDGE FINISHING

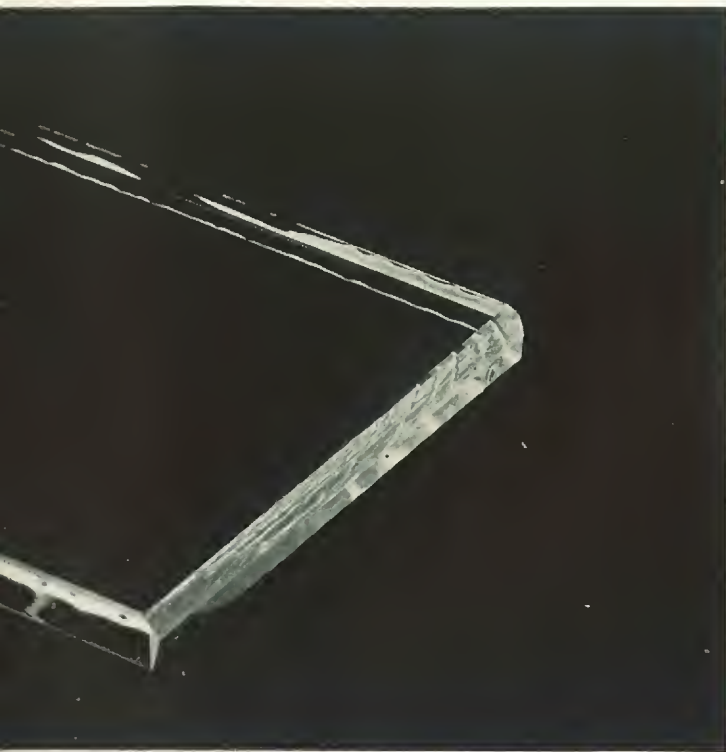
F-2

Edge Finishing

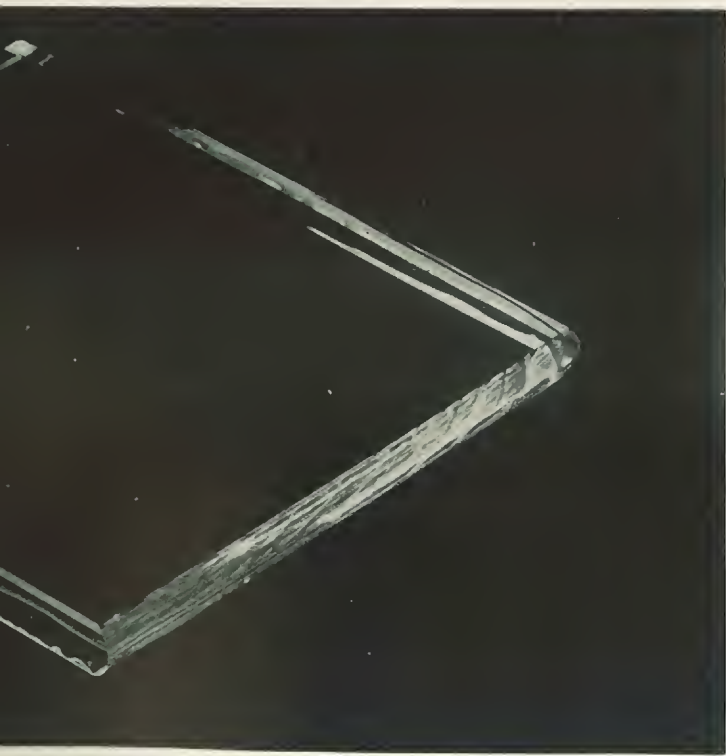
Finishing of glass edges further enhances the beauty and usefulness.



Beveling the edge of rondo-mirror glass is a skilled hand operation.



Polished Quarter Round Edge.



Polished Pencil or Round Edge. Glass pictures actual size, unretouched.

BEVELING

THE beveling of plate glass exemplifies great skill on the part of the workmen, attained only by long training and experience.

Glass to be beveled is subjected to treatment by experts in each particular process from the abrasive grinding away of the bevel section to the restored burnished surface of polished glass.

Five divisions of skilled workmen are engaged in the beveling operation, namely: roughers, emeryers, smoothers, white-wheelers and buffers (polishers), using different abrasive or polishing materials, such as sand or carborundum, emery, sandstone, pumice and rouge.

ROUGHING—The roughing mill or wheel is a horizontal circular cast-iron disc having a fine-cut corrugated surface about 30 inches in diameter. An abrasive is conveyed to the mill from above through a hopper with a fine stream of water. When the edge of the plate is brought into contact with the swiftly revolving roughing wheel, the abrasive, crushed between the iron and the glass, cuts the bevel to the desired depth, while the water minimizes the friction heat. Curved and pattern plates with incurves, miters, etc., require an expert practiced eye and special skill on the part of the operator.

EMERYING—In the first roughing process the beveled surface is cut and scored so deep by the coarse sand that it is necessary to follow with a finer abrasive on another mill to bring the bevel to a smoother finish.

SMOOTHING—The rough ground edge is smoothed on the stone mill, or smoother, which consists of a horizontal fine grain sandstone wheel revolving with water flowing upon it to reduce friction.

POLISHING—Preliminary polishing of the bevel is accomplished by pressing the beveled edge of the glass against the edge of an upright wood wheel which brings the bevel to a dull, milky polish by the use of powdered pumice in solution automatically splashed upon the wheel.

FINISHING—The final high gloss polish is imparted to the bevel surface by contact with the rouge impregnated felt covered edge of a rotating upright polishing wheel.

The preceding outline describes the beveling process generally used by glass fabrication shops.

Precision beveling machines for volume production of beveled plates for mirrors or plaques in rectangles, circles or shapes are used by most of the larger manufacturers.

CLEAN-CUT EDGES

As the term indicates, clean-cut edges are neat cut plates with edges as they occur without special treatment, such as grinding and polishing.

GROUND EDGES

Flat ground edges are obtained by holding the glass at right angles to the grinding wheel using an abrasive material as described in Beveling, except that the work is done on the edge instead of the surface.

POLISHED EDGES

Flat polished edges are obtained by the process described for Ground Edges with the additional smoothing and finishing work to produce polished edges as described in Beveling.

Round polished edges—sometimes called pencil edges—are ground to a semi-circle on a radius equal to half the thickness of the glass, and polished to a brilliant finish.

Half round polished edges are ground to a quarter circle on a radius equal to the full thickness of the glass, and polished.

SWIPED EDGES

Swiped edges are really the first step in producing seamed edges, and are left rough ground. See Chamfered Edges, Seamed Edges.

SEAMED EDGES

Seamed edges are produced by rubbing off the sharp edges with a fine abrasive stone in a uniform manner. Usually seamed edges are very narrow and are left smooth ground. Sometimes edges are seamed on a mitering wheel. See Chamfered and Swiped Edges.

CHAMFERED EDGES

This is done by slightly grinding off the sharp edges of a cut plate in a uniform manner and polishing the ground surface. This produces chamfered edges, usually about $\frac{1}{16}$ inch wide. See Swiped Edges, Seamed Edges.

MITERED EDGES

Mitered edges are usually produced by either



Smooth Chamfered Edge.



Polished 45° Edge Miter.



• The workman forces the belt of the edging machine to follow the contours of the curved cut-out on half circle of plate glass.

of several methods: (a) where available, the so-called precision mitering machine is used in which the glass, on a moving table, is carried past an abrasive wheel in fixed position; (b) where precision mitering machines are not available, small plates are mitered by holding the plate against a fixed abrasive wheel at the desired angle, and moved past the wheel; (c) where the plates are too large for either of the above methods, the mitering is accomplished by nipping the edges (see Nipped Edges) very nearly to the desired miter and then grinding down the ridges to a relatively flat surface by means of a portable power-driven abrasive wheel or by rubbing the ridges down with an abrasive stone moved over the glass with a circular motion, using an auxiliary abrasive paste.

NIPPED EDGES

Nipped edges are produced by scoring a cut on a plate and then snapping off the strip thus marked using a pair of pliers faced with paper, whereby the cut is made to travel very closely from one nip to another. This leaves ridges between snaps and the edge resembles the deckle-edge of paper. See also Rippled Edges.

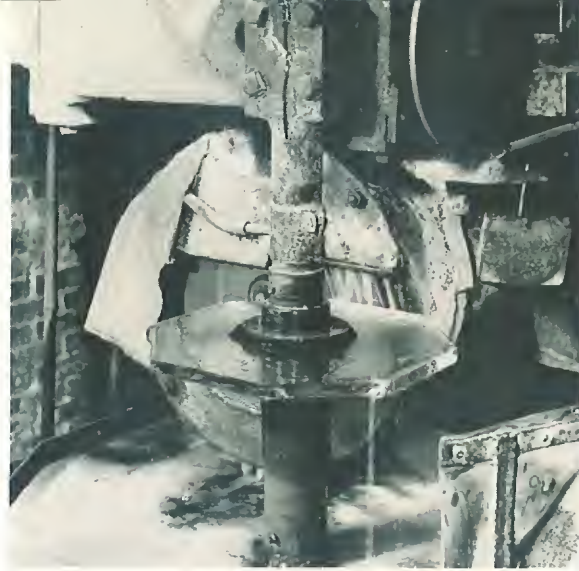
RIPPLED EDGES

Rippled edges are made in the same manner as nipped edges, except that no cuts are placed on the glass. The appearance is much more deckled than nipped edges. See Nipped Edges.

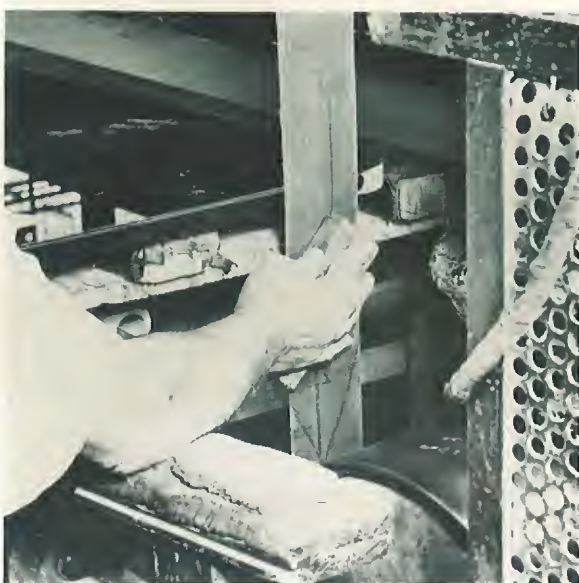
Nipped edges or rippled edges are seldom satisfactory, and consequently are not often used.



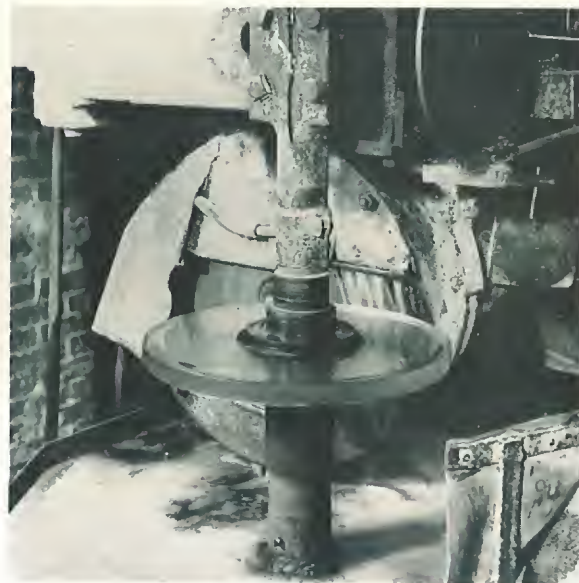
Belt edging a small light.



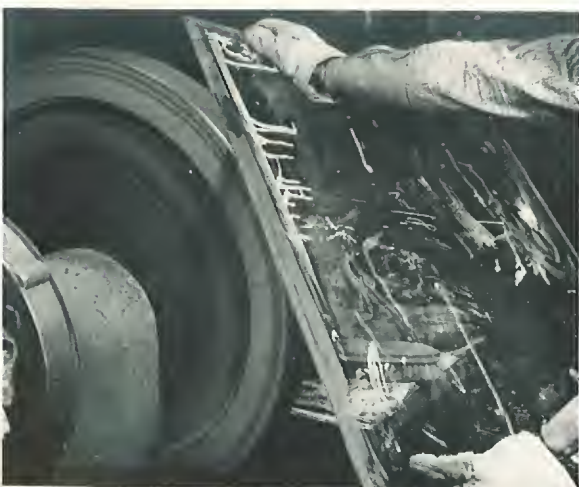
Roughing out a circular plate.



Extra pressure is needed here.



The nearly finished disc.



Polishing a deep bevel.



Edging on the smoothing bed.

VARIOUS EDGE FINISHES

Bevel— $\frac{1}{2}$ inch	
Bevel— $\frac{1}{2}$ inch—chamfered	
Bevel— $\frac{1}{2}$ inch—round	
Miter (45° to sharp edge)	
Flat Edge	
Round Edge } Pencil Edge }	
Half Round	
Chamfered	
Top chamfered	
Bevel— $\frac{3}{4}$ inch	
Bevel—1 inch	
Bevel—1 $\frac{1}{4}$ inch	
Bevel—1 $\frac{1}{2}$ inch	
Bevel—1 $\frac{3}{4}$ inch	
Bevel—2 inch	

Any of these edge finishes may be supplied, except on Herculite products, either ground or ground and polished. Any square edge may be supplied clean cut, ground or ground and polished.

Standard symbols used by the Carrara department are:

Clean Cut...../; Ground.....X; Polished.....※; Ground Miter.....XM; Polished Miter.....※M.

CUT-OUTS

By drilling holes through the glass at the corners of a rectangular cut-out, the glass opening of desired size can be made by cutting with an ordinary cutting wheel or diamond, and the cut carefully tapped out.

Contour cut-outs, not perfectly circular, are made by cutting the pattern of the desired cut-out opening with steel-wheel or diamond cutter and then cutting the glass to contour in the usual way.

Circular cut-outs are usually drilled directly by the use of hollow cylindrical drills and an abrasive. A circular glass core is formed at the same time. Circular cut-outs may be made with the cutting wheel or diamond in the hands of a skilled worker. See Hand Holes and Speak Holes, also Section F-1, Sandblasting.

DRILLING OF HOLES

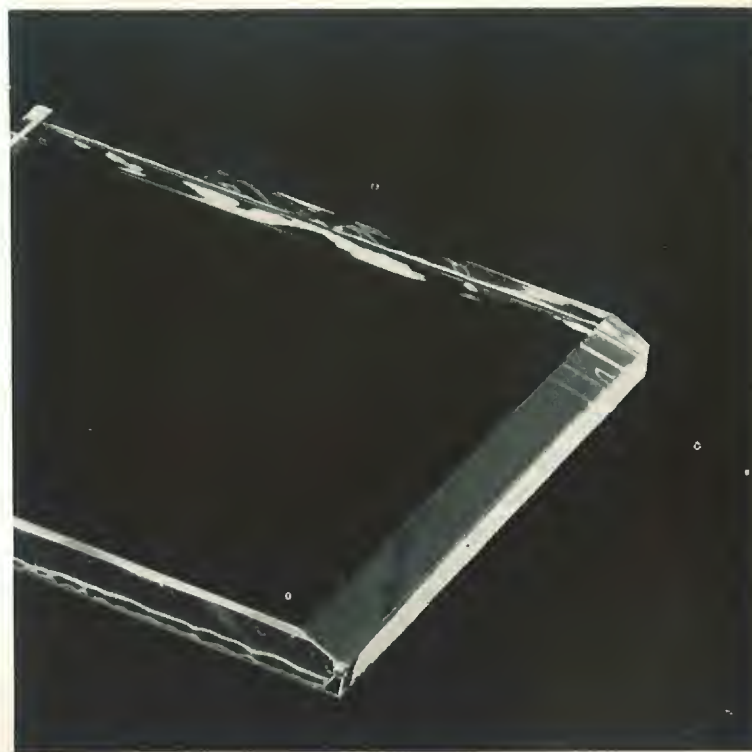
This is accomplished by the use of hardened steel or alloy steel drills in conjunction with emery, or other similar abrasives. Triangular files snapped off at an angle and centered in the chuck so that the point of the broken end shall very nearly but not quite coincide with the center of the hole, make very good drills for small holes up to one inch diameter. Larger holes are usually produced by the method described for circular cut-outs.

SPEAK HOLES

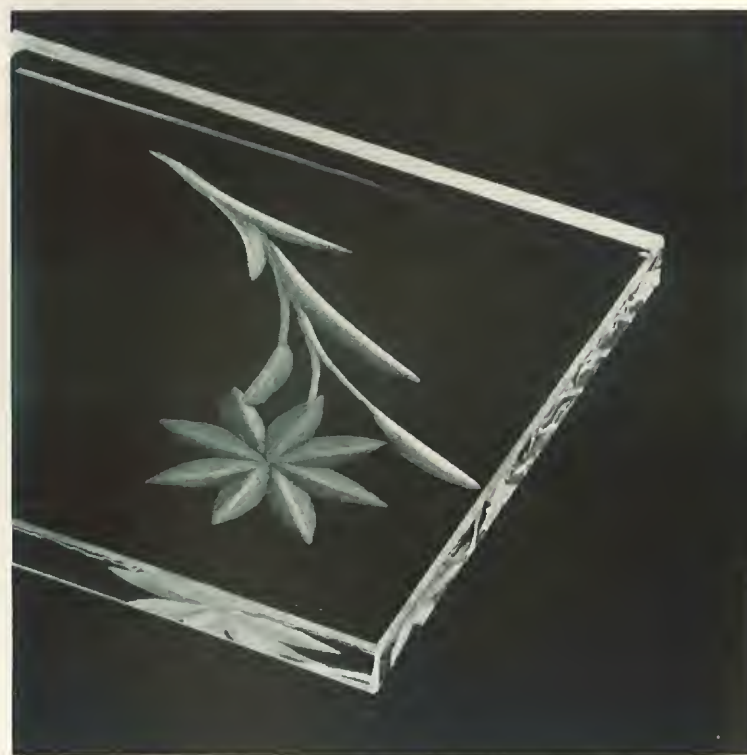
Speak holes are frequently a requirement in glasses intended for use in tellers' windows in banks, theater ticket offices and elsewhere. Frequently semi-circular cut-outs are provided as hand holes in the lower edge of the same plate. Gun-ports often provided in Multiplate Bullet-Resisting panels really come under this same category, and are usually cut through the finished Multiplate assembly, using the hollow cylindrical tube drill technique. In a great many instances, a secondary glass guard plate is mounted behind the speak hole in Multiplate installations as an added protection.

HAND HOLES

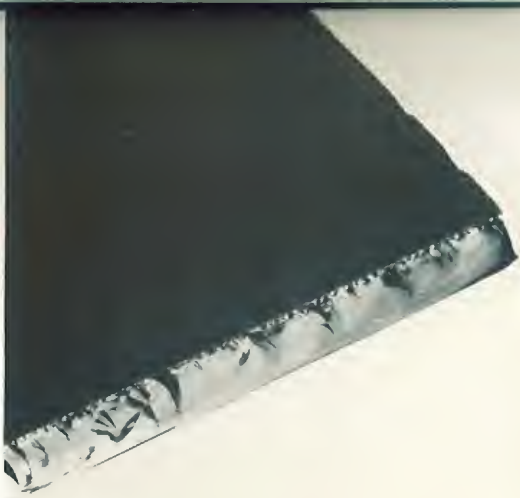
Hand holes are simple special forms of cut-outs or speak holes. They may be circular or oval when in the main body of the plate, or as noted in the preceding paragraph may be cut out at the bottom edge of the glass.



$\frac{1}{4}$ inch Polished Bevel on Clean Cut Edge.



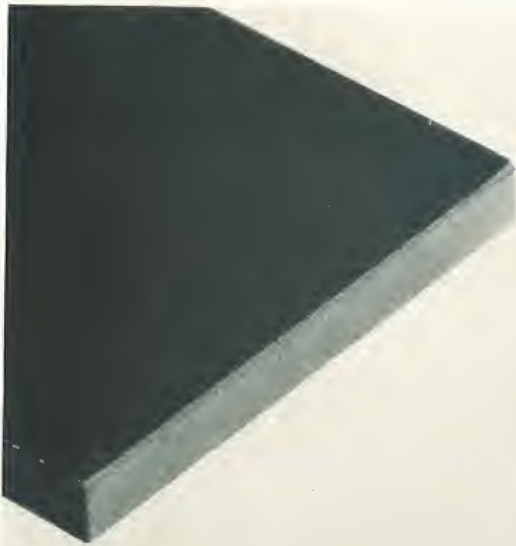
Engraved, with Clean Cut Seamed Edges.



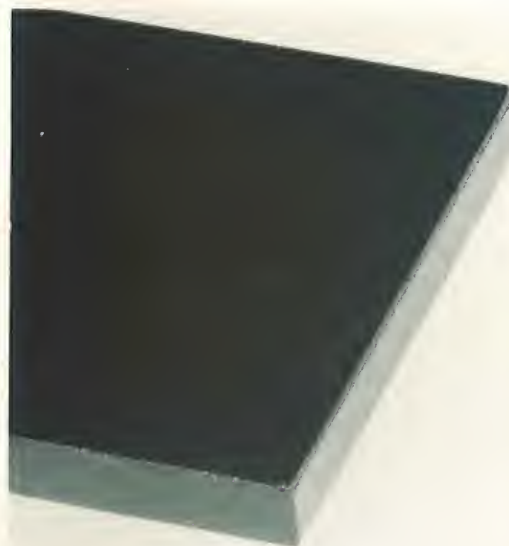
Clean Cut Edge.



Polished Surface, showing cut mark.



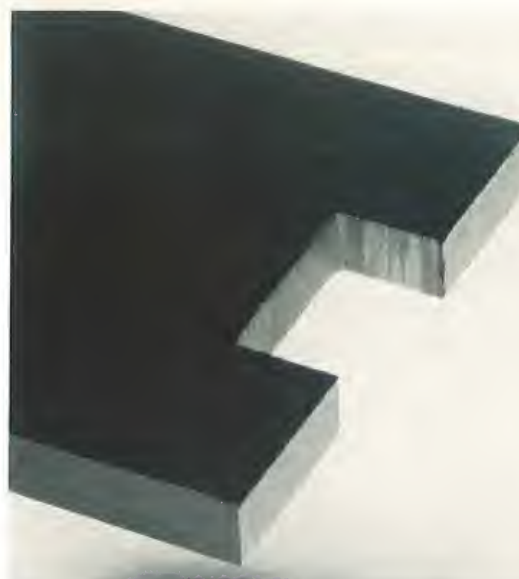
Ground Edge, swiped.



Ground Edge, seamed.



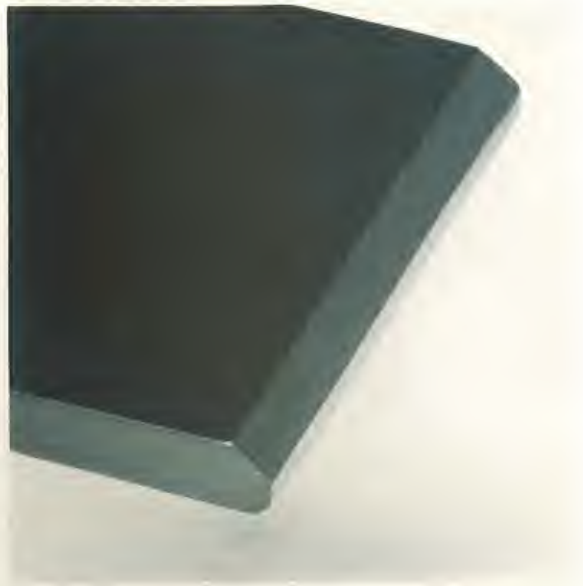
Ground and Polished Edge and Arris.



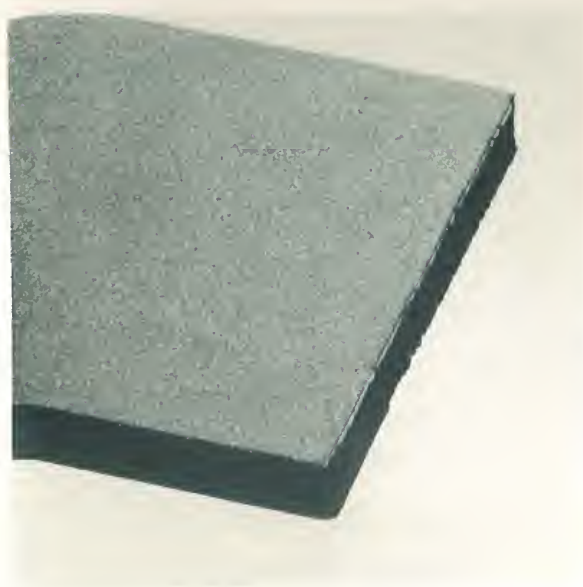
Ground Notch or Cut-out.



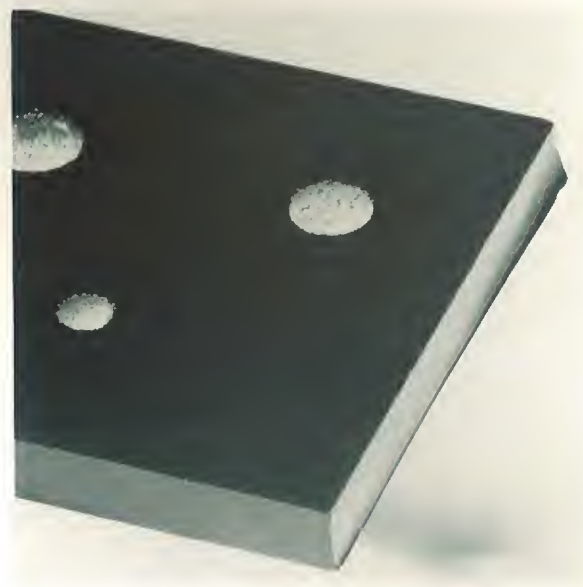
Ground Miter.



Polished Beveled Edge.



Sandblasted Surface.



$\frac{1}{4}$ inch, $\frac{3}{8}$ inch and $\frac{7}{16}$ inch Drilled Holes.

Variations of clean cut edges. These edges should be rubbed down on an emery stone. The edge at right is termed a razor edge and is considered dangerous.

F-3

HERCULITE FABRICATION

Herculite Fabrication

HERCULITE can be fabricated from almost any type of glass that has a smooth surface or a figure rolled surface that does not have deep V-shaped grooves or such deep patterns that the thickness of the thinnest part is less than $\frac{3}{4}$ that of the thickest part.



This test established $\frac{3}{8}$ inch Herculite as a satisfactory material for a stairway balustrade in public buildings.

FIELD FABRICATION

It is not possible to do any kind of fabrication on finished Herculite. Any attempt to grind or chip corners, or sandblast designs in the glass is likely to result in the destruction of the plate. In

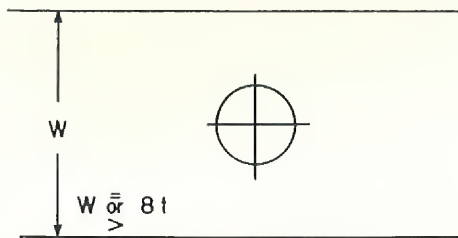
all cases, any such work weakens the plate. However, Herculite that is bowed, because of its great flexibility, may be deflected to put in a frame to the amount specified in the table of allowable deflections mentioned later.

SANDBLASTED DECORATIVE DESIGNS

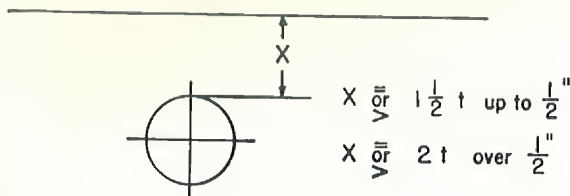
Decorative designs can be sandblasted into glass before tempering to a depth not to exceed $\frac{1}{32}$ inch regardless of thickness. Where sandblasting is on one side only, the plate will be somewhat more bowed than clear glass would be. Sandblasted Herculite is only half as strong as clear Herculite when the sandblasted area is the part stressed.

HOLES, NOTCHES, AND BEVELS

Herculite can be furnished with holes, notches, and bevels that fit the following specifications provided the inner surfaces of the holes or notches are smooth seamed or polished. The right is reserved to consider independently any special fabrication not specifically covered by the following rules:

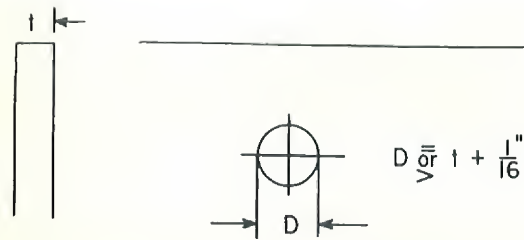


1. *Minimum Width.* The minimum width of glass containing holes which can be satisfactorily tempered is 8 times the thickness of the glass; the other requirements of possible fabrication noted in the following paragraphs must also be met.



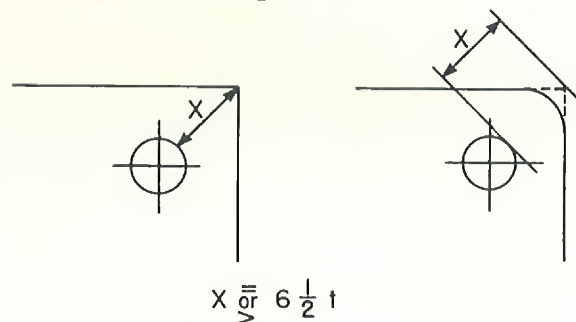
2. *Spacing of Holes.* The distance from any edge of glass to nearest point on rim of hole must be at least $1\frac{1}{2}$ times the thickness of the glass on glass $\frac{1}{2}$ inch or less in thickness; and at least 2 times the thickness of the glass over $\frac{1}{2}$ inch in thickness.

Note: \geq means equal to or greater than.
 $>$
 t means thickness of glass.

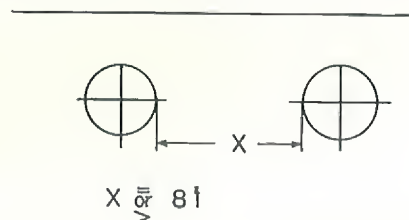


3. *Dimensions of Holes.* Circular holes through Herculite must have a diameter at least $\frac{1}{16}$ inch greater than the thickness of the glass. The maximum size of a hole must not be more than $\frac{1}{3}$ the narrow dimension of the plate.

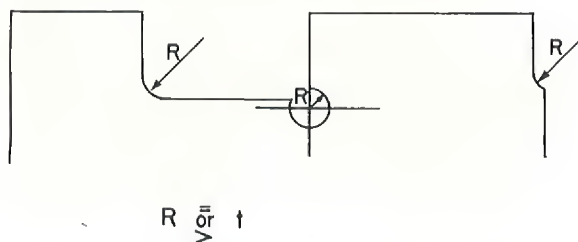
In other than circular holes, any corners must have fillets, the radius of which must be equal to the thickness of the glass.



4. *Holes near corners* must be located so that the nearest edge of the hole is at least $6\frac{1}{2}$ times the thickness of the glass from the tip of the corner.



5. *Distances between rims of holes* must be at least 8 times the thickness of the glass.



6. *Notches and "cut-outs"* must have fillets, the radius of which must be equal to the thickness of the glass, at the bottom of the notch. The right is reserved to refuse fabrication of notches and cut-outs which seem to us to be impractical.

BEVELS

Do not advocate the use of bevels on Herculite because the thin edge, since it heats faster and cools faster, is always more or less warped. If the plates are small, however, this warpage may not be enough to be objectionable. The throat of a tong must be kept reasonably short to prevent shielding too much of the glass, and such tongs will not reach over long bevels to grip the plate. For this reason bevels can never be more than $\frac{5}{16}$ inch wide and on glass less than $\frac{1}{4}$ inch thick cannot be more than $\frac{1}{4}$ inch wide. A great deal of tempered glass has been made with bevels to the satisfaction of the customer, but whenever bevels are furnished it must be understood that there will probably be slight warpage. Bevels must never come out to a feather edge, but must always have a land of at least $\frac{1}{16}$ inch, which must be seamed or rounded.

WARP

Herculite, by the nature of the process, cannot be made as flat as normal plate glass, particularly along the edge from which it is supported in tongs. In general, this deviation from flatness is slight depending upon the thickness, the length of the plate, and other factors. In general, greater thicknesses yield flatter products. Beveled edges require double the tolerance of plain edges.

It is very difficult to measure the bow of large glass plates supported vertically, but extensive statistical study shows it possible to temper $\frac{1}{4}$ inch flat glass to the following tolerances when measured in this manner.

<i>Length of Edge</i>	<i>Deviation from a Straight Line</i>
1'	.020"
2'	$\frac{1}{16}$ "
3'	$\frac{1}{8}$ "
4'	$\frac{3}{16}$ "
5'	$\frac{1}{4}$ "
6'	$\frac{3}{8}$ "
7'	$\frac{1}{2}$ "
8'	$\frac{5}{8}$ "
9'	$\frac{3}{4}$ "

Not all of the glass will be warped this much; in fact, some of it will be much better. The above table represents the deviation that can normally be expected on some of the plates. If one selects the finished glass till 10 per cent of the plates are rejected, he can reduce these tolerances by about

15 per cent. If a 20 per cent loss is assumed, the tolerances can be reduced by about 35 per cent. On glass $\frac{3}{8}$ inch thick, the above tolerances may be reduced by 50 per cent.

If the glass is $\frac{1}{2}$ to $1\frac{1}{4}$ inches thick, the tolerances may be reduced by 75 per cent.

The tolerance for any local kink for any size of plate is .020 inch for any 12 inch span.

When glass is supported horizontally on a perfectly flat surface and the edges held down by weights equal to $\frac{1}{2}$ lb. per running inch to remove the general bow, the deviation can be held to not more than .020 inch from the flat surface.

Bent glass can be made to fit the designated curve to plus or minus $\frac{1}{16}$ inch at any point around the extreme edge. At other points on the surface a fit of less than plus or minus $\frac{1}{8}$ inch cannot be guaranteed.

The other tolerances that can be maintained on tempered glass are as follows:

1. Thickness—plus or minus $\frac{1}{32}$ inch.
2. Rectilinear dimensions—cut edges plus or minus $\frac{1}{16}$ inch. Ground or polished edges—plus 0—minus $\frac{3}{32}$ inch.
3. Diameters external—plus or minus $\frac{1}{16}$ inch.
4. Holes, notches, etc. Internal diameters—plus or minus $\frac{1}{32}$ inch.

Herculite Glass is breakable and when broken cracks up into small more or less cubical fragments. Near temper glass also tends to break in this manner, but with somewhat larger and more elongated particles. Medium temper and partial temper glass tend to break much like regular annealed glass except when the thickness is greater than $\frac{1}{2}$ inch. Any thick tempered glass tends to have a small fracture pattern.

STRAIN PATTERN

Any type of heat treatment leaves a specific strain pattern in the glass which is not normally visible but which may be seen under some conditions when illuminated with polarized light. Perfect heating and cooling distribution will minimize this effect, and while every precaution is taken to achieve this result, some strain pattern is characteristic of all tempered glass and cannot be considered a defect. On Herculite, bent by the wire method, iridescent strain streaks appear which coincide with the bending wires. These streaks can almost entirely be eliminated if there is a large number of plates to be tempered. It is not practical, however, to use this system for tem-

pering only one or two plates. Glass tempered on horizontal molds always has some slight strain marks near the edge where the glass comes in contact with the mold.

TONG MARKS

Tong marks will usually be found along one edge of glass that is supported vertically for heat treatment, and there is no other known method of tempering large flat plates. In most cases when the glass is not too large, they can be put on any edge that the customer desires. These points are weaker than other areas of the plate, and every precaution should be taken in use not to subject this edge to high mechanical strains. In case of glass tempered in a horizontal manner, there are usually slight mold marks not more than $\frac{1}{2}$ inch in from the edge of the plate. These are usually covered by the framing channel and in any event are scarcely noticeable.

DEFLECTION

The great strength properties of Herculite are due largely to much greater allowable deflection than of annealed glass. The performance of Herculite is best therefore under conditions where high deflections are possible. If backed up by an unyielding support over an entire surface or subjected to a blow on the edge and parallel to the surface where there can be little or no deflection, tempered glass is only a little stronger than regular annealed glass.

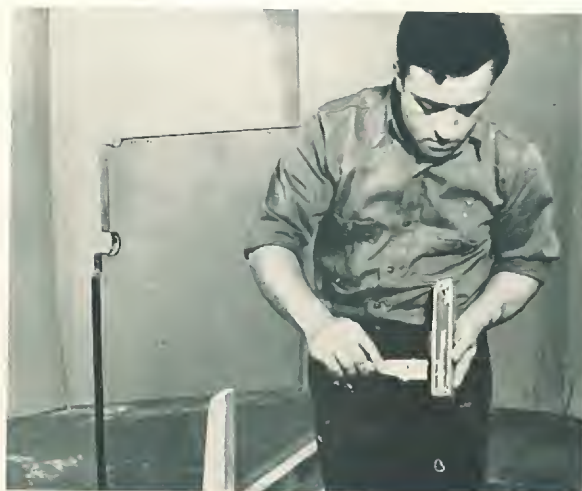
Herculite plates may be safely deflected within the limits established in the following table of allowable deflections. Bowed or warped plates may be safely sprung into a frame within these limits.

ELASTICITY

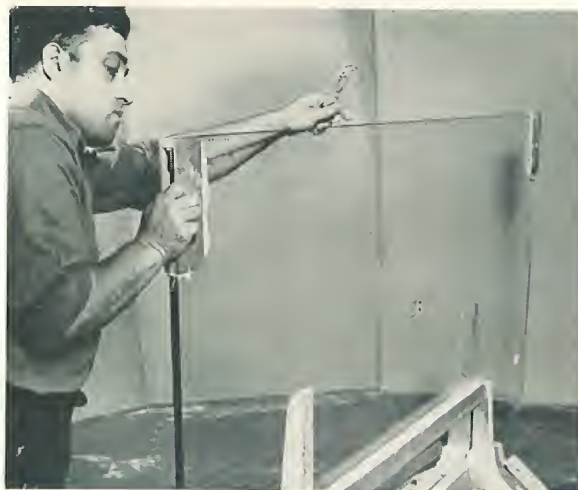
Tempering has no appreciable effect on the modulus of elasticity of glass. This is the force that will produce a given deflection for a given span, thickness, and width of glass plate. Like annealed glass, it is approximately 10,000,000 pounds per square inch.

STRENGTH

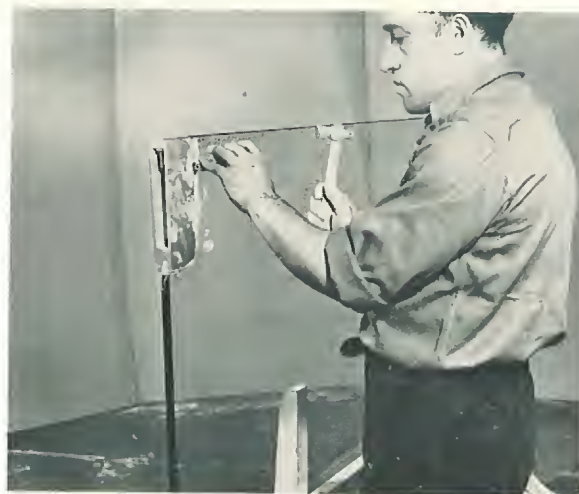
The modulus of rupture or tensile strength of a Herculite plate is approximately 30,000 pounds per square inch provided the tong mark edge is not placed in the area of maximum deflection.



Applying the special cement to the top hinge.



The hinge is accurately aligned.



After the cement has set, it is smoothed up.



After accurate masking, sandblasting cuts the notch.

When this is the case, the modulus may be reduced to about half of this value.

Near temper should have a modulus of about 25,000 pounds per square inch, medium temper about 18,000 pounds per square inch, and partial temper about 13,000 pounds per square inch. These figures may be compared to annealed glass at about 7,000 pounds per square inch.

The above values are true only when the glass is supported in a stress free manner and may be quite different if the glass is subjected to laminating strains or strains caused by uneven framing. These values are true only if the load is applied for a short period of time. For permanent loads these values should be reduced by one-half until such a time that a thorough study is made of this condition and exact values determined.

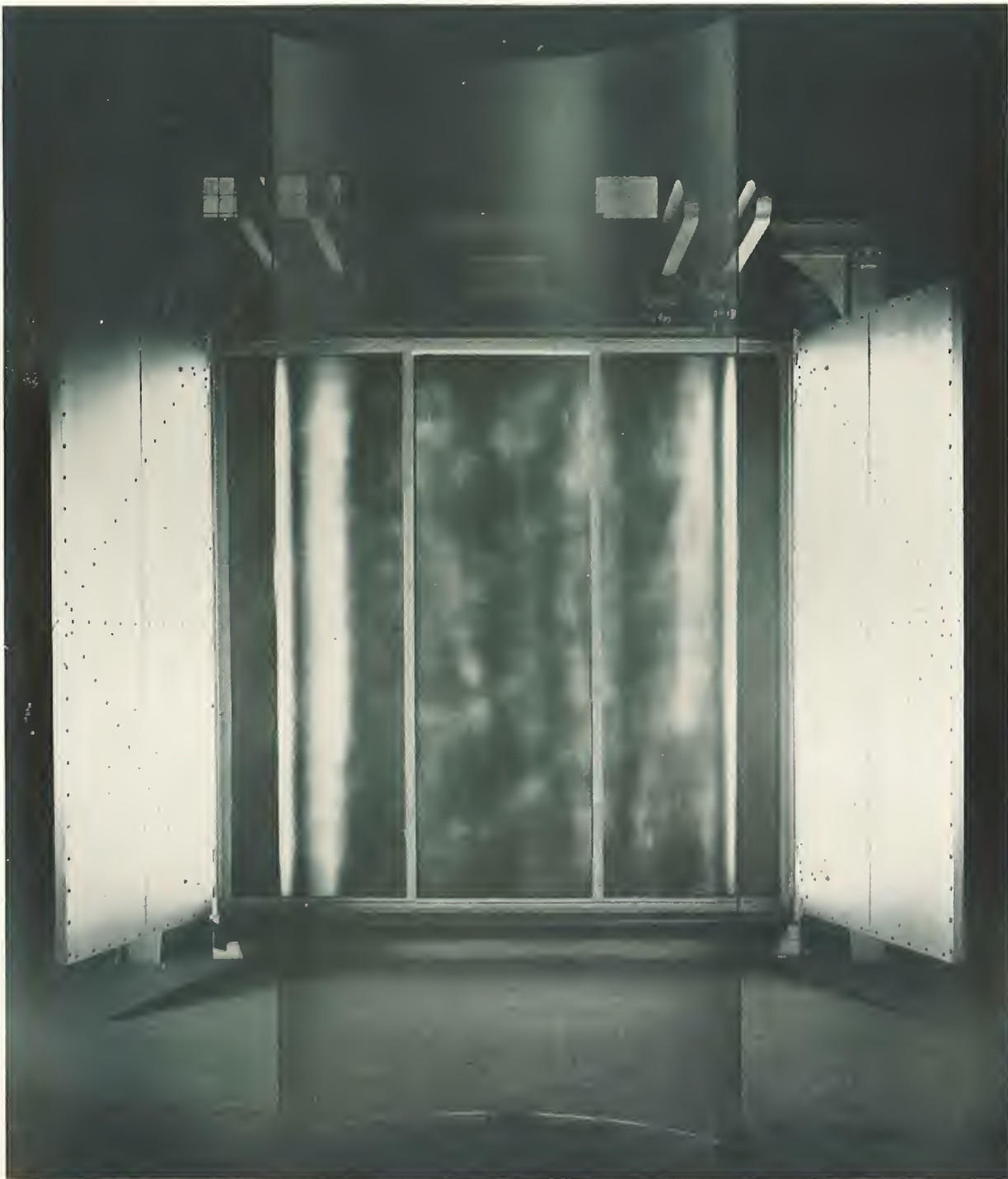
IMPACT

The impact strength of glass depends upon a

great many factors such as size and thickness of the plate, method of support, and probably the most important of all, the velocity, hardness and cross section of the impacting surface of the missile. Under ordinary conditions, however, and with most types of missiles, Herculite can be expected to withstand impacts from 6 to 8 times as great as would crack normal plate glass or laminated glass under the same conditions. See also the paragraph on deflection.

THERMAL SHOCK

The thermal shock a plate of glass will withstand is a function of its tensile strength. Due to the high compressive layers on the surfaces of Herculite, its tensile strength is 4 or 5 times as great as normal annealed glass. It should therefore withstand thermal shocks 4 or 5 times as great. This is true provided the temperatures do not go high enough to partially re-anneal the glass and thus



This polariscope, supposed to be the largest in the world with a seven foot square polarizing screen, is used in the examination of bent glass and Herculite.

remove part of the strain. In theory this may happen at any temperature, but the time it takes to effectively reduce the strain varies from a few million years at room temperature to a few

seconds at 1000°F., in an annealing furnace.

In some types of Carrara Glass, the prevalence of stones or very heavy ream makes tempering expensive. Wire glass cannot be tempered.

Table Showing Allowable Deflection of Herculite Glass
in Inches Based on Factor of Safety of 10

t	$\frac{3}{16}$ "	$\frac{1}{4}$ "	$\frac{5}{16}$ "	$\frac{3}{8}$ "	$\frac{1}{2}$ "	$\frac{5}{8}$ "	$\frac{3}{4}$ "	1"	$1\frac{1}{4}$ "
L	Allowable Deflections								
12"	.038	.029	.023	.019	.014	.012	.010	.007	.006
18"	.086	.065	.052	.043	.032	.026	.022	.016	.013
24"	.154	.115	.092	.077	.058	.046	.038	.029	.023
30"	.240	.180	.144	.120	.090	.072	.060	.045	.036
36"	.346	.259	.207	.173	.130	.104	.085	.065	.052
42"	.470	.353	.282	.235	.176	.141	.118	.088	.071
48"	.614	.461	.369	.307	.230	.184	.154	.115	.092
60"	.960	.720	.576	.480	.360	.288	.240	.180	.144
72"	1.382	1.037	.829	.691	.518	.415	.346	.259	.207
84"	1.881	1.411	1.129	.941	.706	.564	.470	.353	.282
96"	2.458	1.843	1.475	1.229	.922	.737	.614	.461	.369
108"	3.108	2.333	1.866	1.554	1.166	.933	.778	.583	.467

t = thickness of glass

L = length of plates or span in inches

SECTION "G"

PITTCO STORE FRONT METAL

PITTCO STORE
FRONT METAL

G

G-1

PITTCO STORE FRONT METAL

Pittco Store Front Metal

The Origin, Design and Manufacture of Pittco Store Front Metal present an outstanding example of the progressive spirit of the Pittsburgh Plate Glass Company.

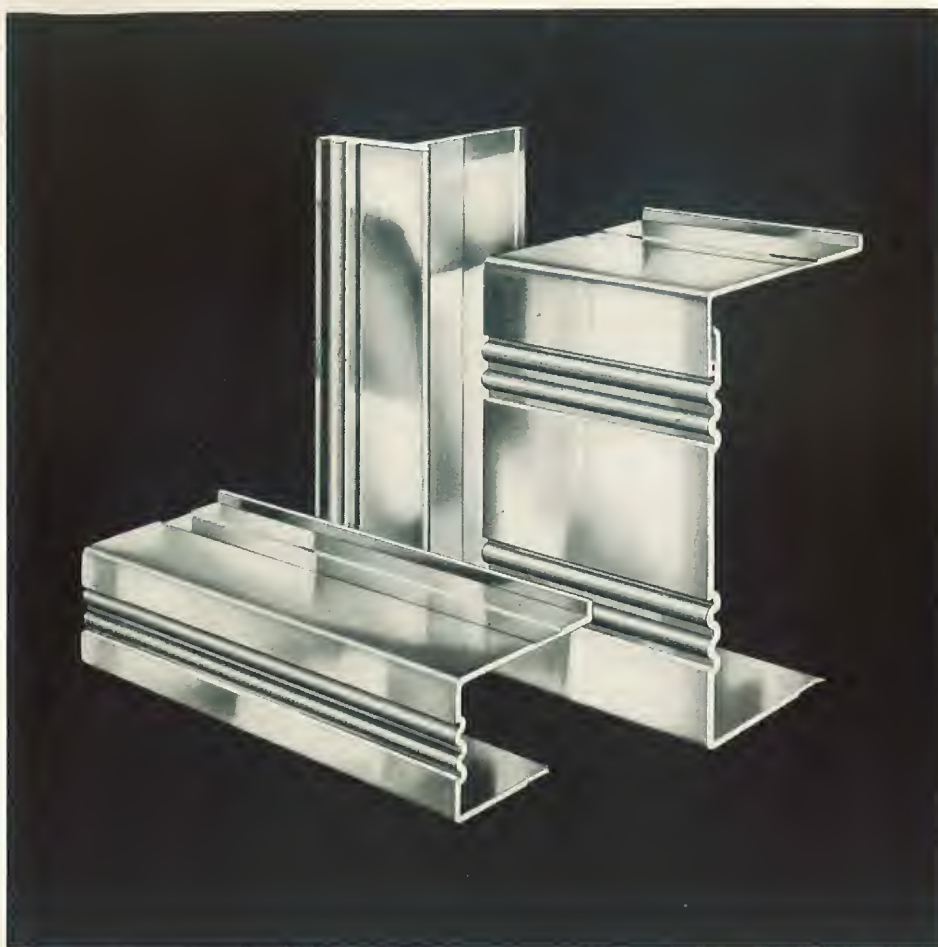


A striking store front of Pittco metal and Carrara and plate glass.

THE Pittco Store Front Division, while intimately tied into the Company warehouse system, has the same wide diversification of contacts as the other principal divisions of the Company. Through its efforts, Pittco Store Front Metal has received the unqualified approval of many nationwide organizations and is specified generally by

architects throughout the United States and in many foreign countries.

The introduction of Pittco Store Front Metal in 1934 was an experiment. Previous to that time, the Company had no formally organized store front sales organization, although the warehouses sold many store fronts using Easyset Store Front



Unity of design in all mouldings is beautifully illustrated above. No salesman ever had to apologize for any incongruity in the character, finish, weight and practicability of a Pittco Metal Store Front member.

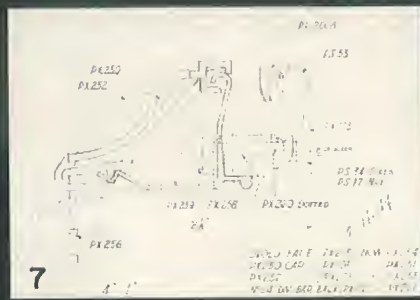
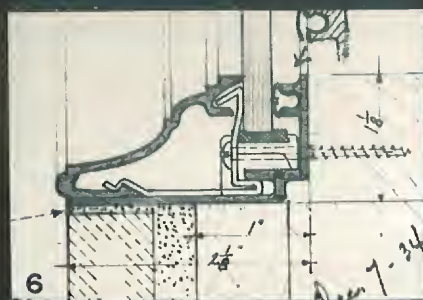
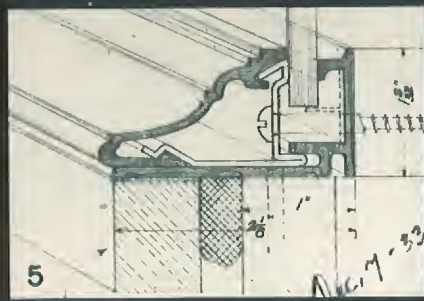
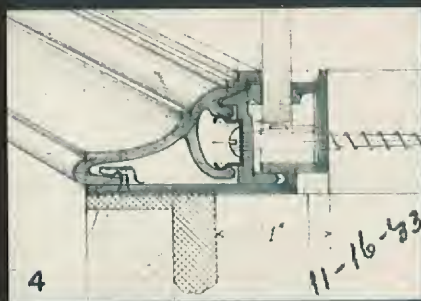
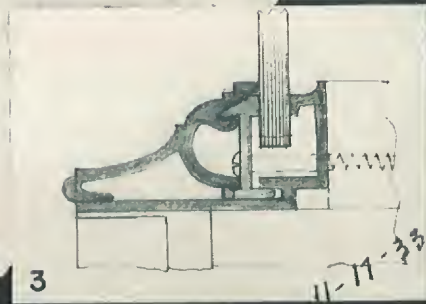
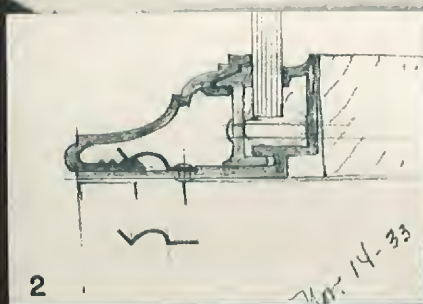
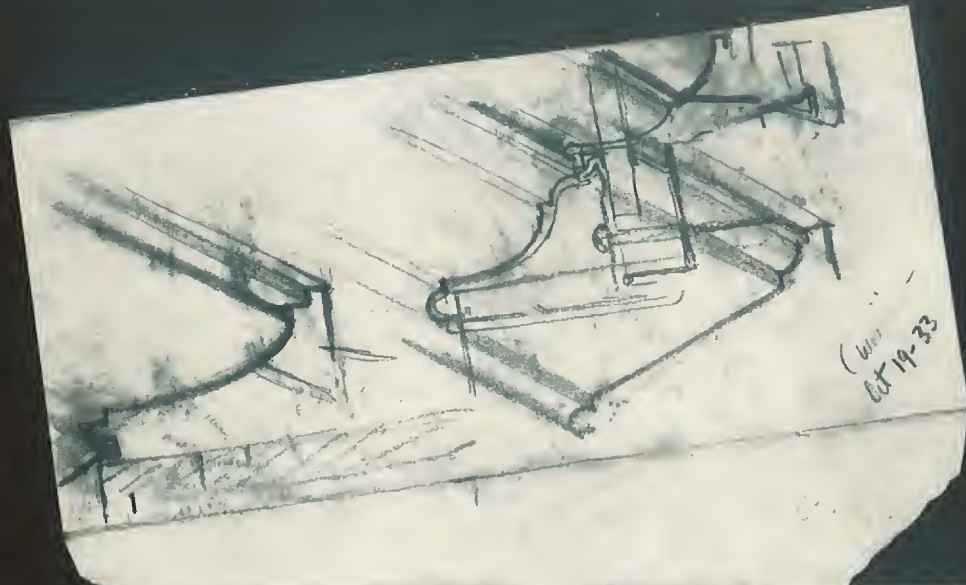
Metal. This Easyset Metal was formed of cold rolled aluminum, bronze or stainless steel members. The use of extruded metal for store front construction was limited almost exclusively to custom-built designs for the elite stores in metropolitan areas. The majority of those installations embodied the use of setting beads or stops with exposed screws, and the glass embedded in putty.

In the fall of 1933, the officials of the Company who were charged with guiding the sale of the standard rolled metal recognized a new era, an era that called for something new in metal, something refreshing and worthy to be associated with the beauty of Carrara and the many other fine products of the Pittsburgh Plate Glass Company. They became interested in introducing a new type of store front metal formed from aluminum or bronze by the extrusion process.

The whole program was novel and there was only one course to follow for its development. A standard line of extruded mouldings must be designed, providing concealed fastenings, and the finished product must be stocked, ready for shipment. This had not been tried before on an extensive scale, and the venture was entirely speculative.

The design of a new system of store front metal depends primarily upon consideration of the sash itself. This part is the most widely used, and is responsible for the support and protection of the glass. From it spring the many other mouldings that are essential to the construction of a front. Hence, the character and lineage of the mouldings, if correctly designed, show a pleasing relationship to the sash.

Prior to the advent of Pittco Store Front Metal there were numerous types of metal construction



Few realize how much midnight oil is burned in the creation and development of a new product. All too frequently we look at the finished job and regard it as something that just happened. The original sketch of Pittco began on the back of an envelope, a reproduction of which is shown by panel 1, above. Studies 2, 3 and 4 were stepping stones to 5 which shows how the first sash was made. Closely following 5, tools and dies were changed to include the improvements shown in 6. Note the addition of the stainless steel cushion. The new and improved postwar construction with all related parts is shown compositely in panel 7.



A die is a precision made tool.

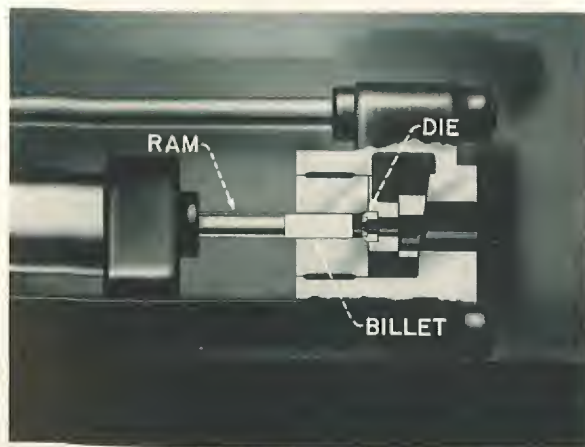
on the market but a close similarity existed between them. The general dimensions of the sash were about 1 inch high by 1¼ inches deep and the industry failed to deviate from this seemingly fixed size, probably for want of creative ability and fear of increased cost. The mouldings were more or less of a hit and miss pattern instead of appearing to belong to one family. It was then to be learned if the new extruded Pittco Store Front Metal would fall in line and become just another group of mouldings or if the Company would be bold enough to try something entirely different. Fortunately, the latter course was chosen and the acceptance of the revolutionary design was immediate and beyond all expectations.

The reasons for this success are many. Important contributing factors, however, can best be expressed by quoting some of the claims which were made in the original announcement of Pittco De Luxe:

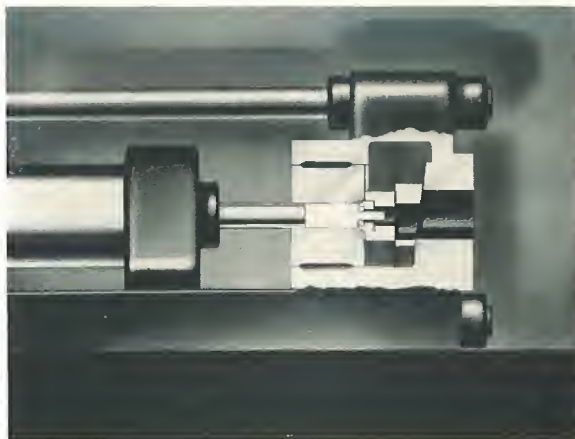
- (a) "A new style sensation in metal store front construction."
- (b) "Plainly exhibited in all mouldings is a pleasing harmony and relationship of design."
- (c) "Each member is extruded with clearly defined contours, with sufficient strength to resist severe abuse."
- (d) "A sash made like armor plate yet with the grace of a Corinthian base, a cushion grip on the glass as soft and yielding as a finger grip."
- (e) "Combining De Luxe with Carrara produces an air of unmatched elegance and refinement."
- (f) "The modest, unobtrusive contours of faces and generous depth of sash form an appropriate and pleasing frame for all classes of merchandise."

Following the design of Pittco Store Front Metal, there arose the problem of where it would be manufactured. Due to the uncertainty of the operation, it did not command much attention. As a result, the production of Pittco Store Front Metal was first established in a single story frame building remotely situated in a corner of the Creighton property on the bank of the Allegheny. The area of this building was a little over 17,000 square feet.

In a few brief months it became evident that expansion would be necessary to meet the ever



The Three R's of Metal Extrusion.



The billet submits to superior force.

increasing needs of the warehouses. They had done an excellent job of merchandising Pittco Store Front Metal and the consumer demand for the product was insistent.

After thorough consideration, it was decided that the most suitable location for the new and enlarged home of the Division was Kokomo, Indiana, where the Company owned some buildings in which glass formerly was manufactured. One of these buildings, which had served as a machine shop, was a rather modern structure having a floor area of about 30,000 square feet. The production of Pittco Store Front Metal was transplanted to Kokomo, where it is manufactured today, in the plant known as Works No. 19.

One of the most fascinating of all known metal-working processes is hydraulic extrusion.

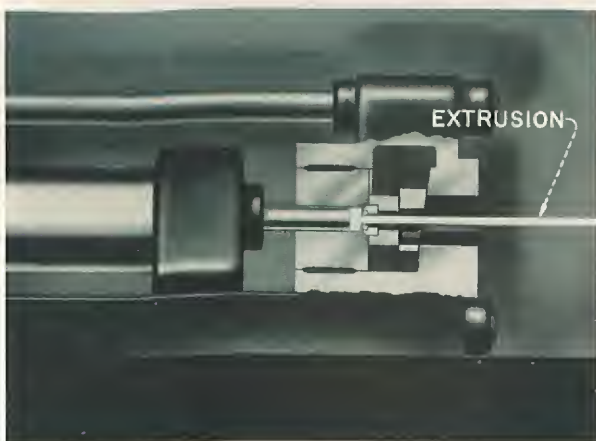
This process may be compared to the methods of forcing heavy lubricants into the bearings of an automobile. The metal is heated to a semi-plastic state, placed in a receptacle immediately behind the extrusion die and is forced through the die by hydrostatic pressures up to 5,200 tons. The die is made from special hardened steel which is cut out very accurately to the exact contours of the desired moulding. The extrusion process insures more perfect surfaces, better color, sharper lines and stronger



Some extrusion presses are huge machines.

and more substantial Store Front construction.

The photographic illustrations on this and the opposite page show some of the more important steps in extruding metal, from the time the billet is placed in position until it leaves the press as a finished moulding.



Thus the process is carried to completion.



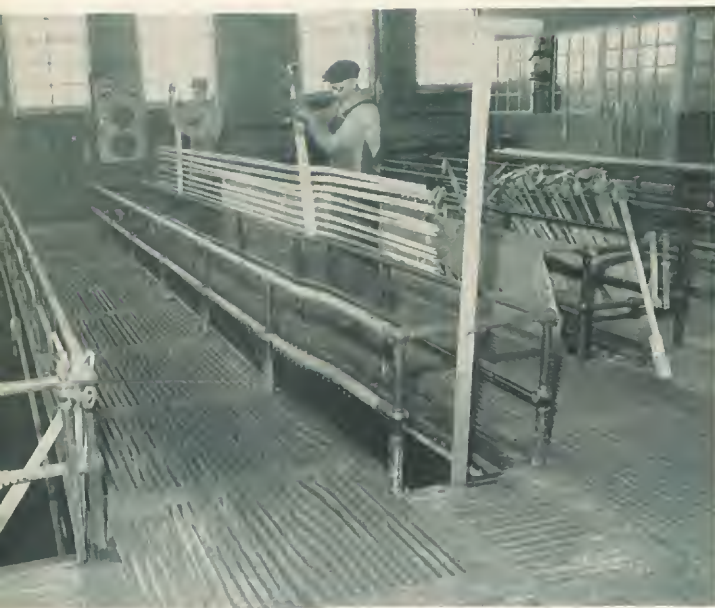
A few of the many Pittco De Luxe extruded shapes.



Top, left

BUFFING: In order to bring forth the true richness of Alumilite, the surface of the metal must be thoroughly prepared. All exposed Pittco mouldings are buffed to a mirror-like finish before they are Alumilited. Modern equipment and methods are employed in this operation to assure the ultimate in color and texture.

Center, left



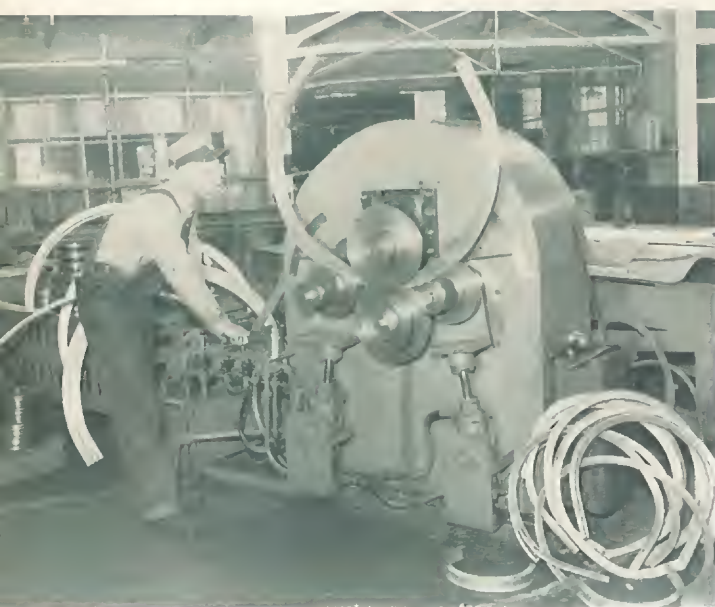
Lower, left

MACHINE CURVING: In an effort to produce curved metal faster and better, many popular Pittco mouldings are curved in this bending machine. Each shape requires a special set of bending rolls, the cost of which runs rather high. It would not be economy, therefore, to curve the less popular items in this manner.

Top, opposite

LEAD CURVING: This method has been employed over a period of many years. It is particularly suitable for special shapes or infrequently used mouldings. Molten lead is cast around the entire surface of the moulding. This casting is placed on a steel table and roughly bent to template. The lead is melted away and the moulding worked down to within $\frac{1}{32}$ " of the radius required.

Center, opposite



PRESS WORK: Produced on this machine are Pittco caps of various types, bar anchors, clips and many other accessory items. The photograph shows an operator passing a moulding through a die that is accurately spacing and piercing holes at each stroke of the press. The punch press is perhaps one of the most useful machines in the Pittco metal plant.

Lower, opposite

BRAKE MACHINE: The first step in producing a brake moulding is to determine the required width of the sheet metal. This is sheared from a large sheet. The operator then marks off where each brake will occur and places the sheet between the jaws of the brake so the shoe is exactly at the point where the brake is to be made. The side lever is lowered, causing the bottom apron to rise against the metal, thus forming the brake.

Development and improvement of Pittco Metal store front construction has been continuous and, as a result, the Company now offers two styles of Pittco store front construction known as Pittco De Luxe and Pittco Premier.

As its name implies, Pittco De Luxe is the finest line of store front metal that inspired design, modern ingenuity and superior materials and workmanship has ever produced. It is primarily a quality construction intended to provide a maximum invitation and sales appeal to the passer-by.

Pittco DeLuxe was designed as a complete line of units to meet every demand which today's store front could make upon a metal construction. Except for certain minor additions and improvements, it is the same today as when originally produced. The pleasing relationship each member bears to all others, its distinctive and refreshing styling, its versatility and proved practical advantages, have made Pittco De Luxe an unrivaled favorite with leading architects, builders and property owners. Many thousands of installations which have been made since 1934 bear witness to its durable and practical qualities.

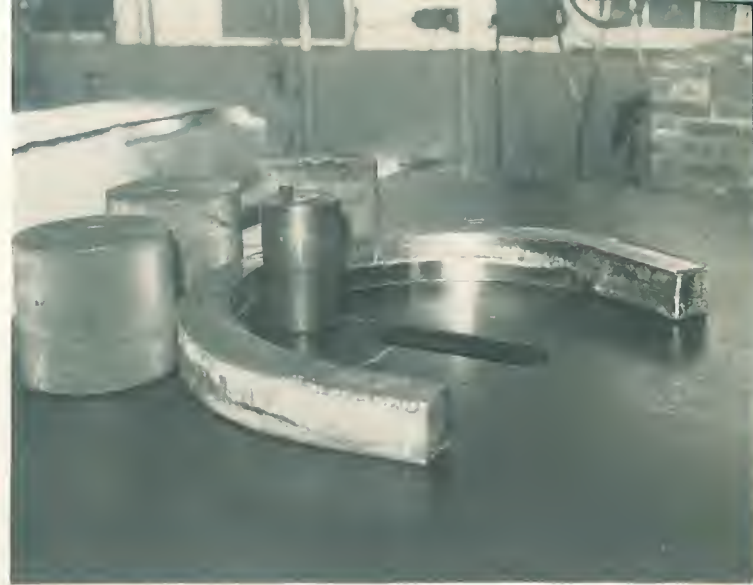
Pittco De Luxe is as practical as it is beautiful. All setting operations are performed outside the show window, which makes it especially easy to install. It provides a special cushion grip on the glass which effectively protects the glass against strains and jars.

Pittco De Luxe Store Front Metal is available in clear, lustrous Alumilite® and beautifully finished Architectural Bronze.

Pittco Premier is a new lightweight store front metal of outstanding beauty and versatility. It is the result of painstaking craftsmanship applied to quality materials and it embodies improvements in styling, design and setting procedure which architects, contractors and merchants were quick to appreciate, and utilize.

Pittco Premier was designed as a complete line. The individual members are deliberately styled to be used together and to complement each other

®Alumilite is the trade name for finish which is electrochemically produced on aluminum by the anodizing process. It is a hard, glass-like finish which may be cleaned easily with a neutral soap and water. The Alumilite surface is approximately 20 times harder than the untreated aluminum. The Alumilite finish is applied to all aluminum Pittco Store Front Metal. The Alumilite finish is subject to attack by wet mortar, plaster, whitening, strong alkalis, cleaning acids and similar materials. It is recommended that the finish be protected during building operations by the use of masking tape or suitable wax to avoid the possibility of disfiguring stains.



in creating store fronts of true distinction. The line is distinguished by a high degree of architectural symmetry in which each element bears a harmonious and planned relationship to every other element of an installation.

Pittco Premier represents the greatest advance in setting practice in many years. Its installation is quicker, easier and safer than that of any other store front metal available. The setting operations are carried on entirely from the outside and the procedure is so simple and easy to perform that substantial savings in setting time are effected. When replacement of glass is necessary, window displays need not be disturbed—the new glass may be installed entirely from the outside with amazing speed and minimum difficulty. The Pittco Premier sash adjusts itself to various glass thicknesses and maintains a firm, strong grip on the glass at all times. It may be provided with drainage facilities when required.

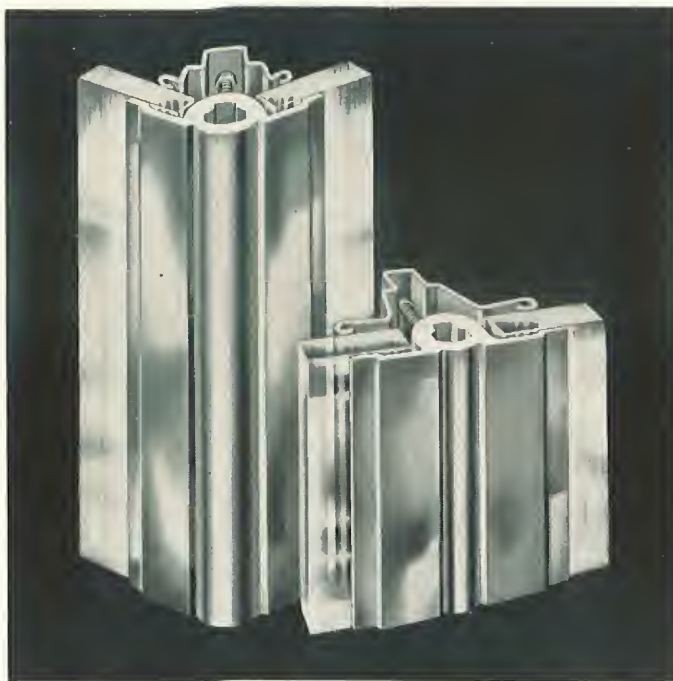
Pittco Premier Store Front Metal can be supplied in Alumilite, Architectural Bronze or Stainless Steel. It is lighter in weight and provides a shallower reveal for show windows than its distinguished companion line, Pittco De Luxe. Pittco Premier is a truly great contribution to the mod-

ern science of effective display of merchandise.

Both Pittco De Luxe and Pittco Premier Store Front Metals comprise all of the mouldings and units essential to the erection of a modern store front. The shapes may be combined into separate assemblies to meet practically all store front requirements.

With the addition of Premier and the Company's decision to manufacture all of its metal store front requirements, an expansion program is now underway that will increase the floor area to 100,000 square feet. The completion of the new plant will assure greater efficiency and ultimately better service, which the Company's dealers and warehouses have so well earned.

Pittco metal may not rank as a major Company product insofar as volume is concerned. It is highly essential, however, to the sale of practically all Pittsburgh Plate Glass Company products, including paint. Due to its many outstanding qualities and advantages, Pittco Store Front Metal has eased the way to many sales that may otherwise have gone to competition. It is worthy of the Company's name and its growth from a 17,000 square foot plant to one of 100,000 fully demonstrates the established merit of the product.



Installation Services

This section will afford a general idea of the various services which the Company is prepared to render to its customers. It cannot cover in detail all the ramifications of the services nor even to a degree the extent of effort which the Company stands ready to expend in developing new and efficient utilization of glass.

The Products Development Department is charged with the responsibility of seeking out new applications for glass—and assisting in developing satisfactory methods of installation and modifying glass for use in those applications. It will welcome inquiries covering installation methods, old or new, and will render every assistance at its command in solving those problems.

SECTION "H"

INSTALLATION SERVICES

H - 1

GLASS AND GLAZING CONTRACTS

H - 2

PITTCO STORE FRONTS

H - 3

CARRARA STRUCTURAL GLASS INSTALLATION

H - 4

STRUCTURAL MIRROR INSTALLATION

H - 5

AUTO GLASS PARTS

H - 6

REPLACEMENTS

H - 7

GLASS FLOORS

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AQUARIUMS

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SKYLIGHTS

H - 10

WINDOWS

H - 11

PC GLASS BLOCK INSTALLATION

H - 12

PC FOAMGLAS INSTALLATION

H - 13

SPECIAL INSTALLATION DETAILS

INSTALLATION
SERVICES
H

INSTALLATION
SERVICES

H

Glass and Glazing Contracts



Often the glazier must become a rigger, as in setting this very tall window.

BECAUSE of the pre-eminent position of the Company, architects who have new projects in prospect frequently call upon the warehouse staff for specialized technical information on the uses of glass which may be applicable. Very often this brings new projects to attention long before they become a matter of general knowledge.

In addition, each of the warehouses subscribes to information services, agencies which specialize in reporting work in progress in various architectural offices throughout the country. In many instances, these services are able to inform the warehouses some time in advance of the formal letting of the building contracts to a general con-

tractor. If the project is a large one, a member of the warehouse staff, known as a plan surveyor will visit the office of the architect and thoroughly examine the blueprints of the proposed job, determining therefrom the total number of openings that require glass and the size and kind of glass applicable to each opening. This information is returned to the Estimating Department for future appropriate use.

When bids are sought, the competing general contractors will request the warehouse to proceed to the office of the architect and take-off the glass and glazing, and to submit a quotation.

The inquiries from the contractors are handed to the Estimating Department together with the take-off data and an estimate to cover glass and glazing, labor and materials, is sent to the contractors. As soon as the general contract is let, the Contract Department of the warehouse will negotiate for the glass and glazing contract. Each of the warehouses maintains a Contract Department fully equipped to handle the contract.

Upon closing of the transaction, the Contract Department schedules the work to be done and is charged with the responsibility for completing the job on schedule.

This phase of the Company's operation is extensive in scope from the point of view of glass products sold and the wide variety of applications involved. A typical breakdown is as follows:

I. GLASS AND GLAZING—

Window Glass and Plate Glass,
Industrial and Institutional

II. STORE FRONTS

III. RESIDENTIAL

Windows, Bathrooms, Kitchens, Window
Sills, Doors and Mirrors

Each of these classifications is handled as just described for general glass and glazing contracts.

I. GLASS AND GLAZING

Most industrial window glass glazing, both for steel sash and wood sash, is done at the site by the Company's regular glazing crews. The work is so scheduled that there will be no costly waiting time. Glass, cut to proper size—putty—scaffolding—and all tools are on the job when the glaziers arrive and an experienced glazing foreman is put in charge of the operation. He is given a copy of the specification and reports job progress to the warehouse glazing superintendent or contract

manager. Accurate records are kept as to costs per light, type of job, and other pertinent data.

The building owner may specify the glass product which he desires used in the sash which he has purchased.

The residential field presents a large demand for Carrara bathrooms, Carrara kitchens, mirrored powder rooms, fireplace mantels, structural mirrors, framed door mirrors and decorative mirrors of various kinds, table tops, window sills and offers a tremendous market.

Industrial glass and glazing contracts often include the interior installations as well as windows. These may cover building entrance ways, hallways, office partitions, toilet rooms and other similar applications. Many interior applications such as toilet rooms particularly, offer an ideal opportunity for the installation of Carrara wainscot, toilet stalls, stiles and partitions, shower stalls, window sills and many others.

II. STORE FRONTS

Store front installations involve the use of virtually all of the Company's products. Unquestionably, the Pittsburgh Plate Glass Company is the leader in the store front field as a result of research, design and engineering departments and the store front installation experts of the warehouse, all of whom co-operate very closely with the architect.

New and remodeled store front installations represent a considerable volume per year and give the warehouses an excellent opportunity to market the Company's products in a field where they may be most advantageously displayed.

III. RESIDENTIAL GLAZING

Single and two-family dwellings, and small apartment houses use considerable quantities of plate glass and window glass, although much wood sash is glazed by the wood sash manufacturer who usually purchases the glass and glazes the sash at his factory.

Residential glazing may, to a very great extent, follow the same procedure just outlined for industrial glazing. However, because individual residential jobs are relatively small, they present a problem which may result in a loss unless carefully planned and managed.

The installation is handled by the glazing department. The original measurements are rechecked, the glass ordered from the warehouse cut to size. The glass is taken to the job by Company

trucks and glazed in accordance with the requirements of the construction.

The illustration on the leading page is typical of the problems encountered in general glazing. It shows a most unusual installation involving great ingenuity on the part of the glaziers. It was carried out by the warehouse at Philadelphia, and the operation included the setting of two separate windows, each 228 $\frac{3}{4}$ inches high by 119 $\frac{3}{4}$ inches wide. Each glass weighed approximately 700 pounds. The glass was cut to size at the warehouse, but notches to allow for lugs in the framing had to be cut on the job.

The glass was carried to the job in the A-rack of the truck. A special cradle was built to handle the glass at the job, and was carried in the body of the truck. At the job the cradle was braced on edge, lengthwise, and the glass lifted from the side of the truck into the cradle which had been lined with drop cloths to cushion the glass. Four braces were put on the open side of the cradle to hold the glass in place.

When the glass was secured in the cradle, the towmotor hook was inserted into a 1 $\frac{1}{4}$ inch eyebolt

in the narrow end of the cradle and the cradle lifted on end, thereby placing the glass in an upright position, 19 feet high.

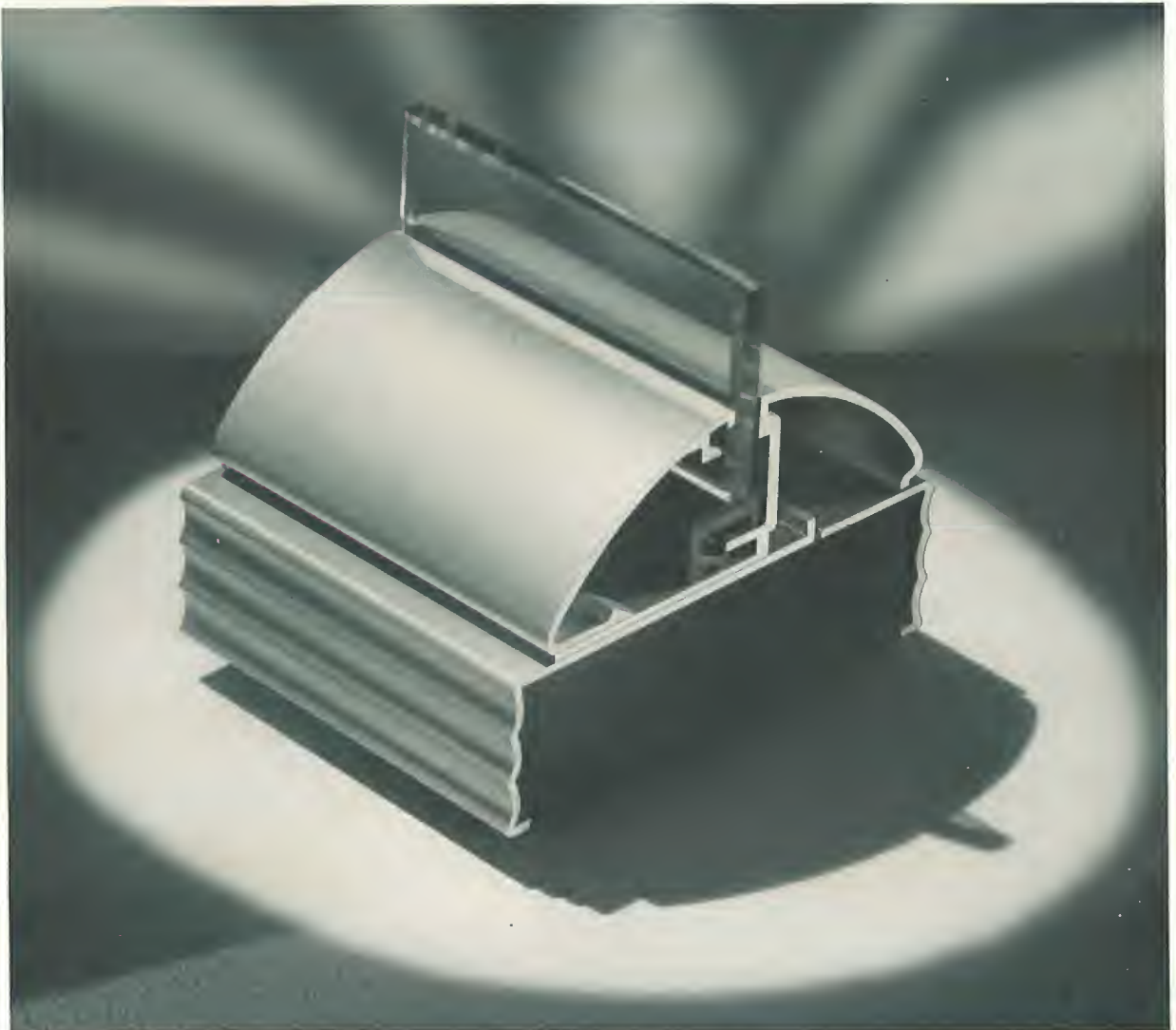
The glass was set into Pittco No. 10 sash, which had previously been prepared. A scaffolding had been set up inside the opening to facilitate handling the glass. The towmotor carried the crate to the opening and set it on a platform erected immediately in front of the window. The towmotor crane held the cradle and glass steady while the braces were removed. The glass was lifted out of the cradle to the platform by eight men with four straps on the bottom of the glass while two men, one above the other on each side, and two men at the top, assisted in guiding the glass into place.

When the glass was out of the cradle, and resting on the platform, the towmotor moved the cradle back about 18 inches from the glass and left it to act as a windbreak to protect the glass. The men then lifted the glass, carried it about 18 inches, and set it into the frame.

The same procedure was followed in both windows, without mishap of any kind in a total elapsed time of 12 hours—6 hours for each plate.

Pittco Store Front Metal

The warehouse installation department co-operates with the architect in supplying additional detail and layout drawings as may be required for the specific project.



The beautiful symmetry of design which may be obtained with Pittco De Luxe Store Front Metal construction is well illustrated in this sectional photograph of Pittco De Luxe No. 15 Sash.



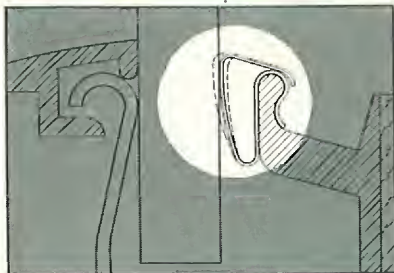
Shown above is 12-A De Luxe sash and sill 195. In this combination, the clean arc of the sash face enhances and intensifies the fluted sill and jamb member. All DeLuxe sash can be installed from outside, a desirable feature in any glass setting.



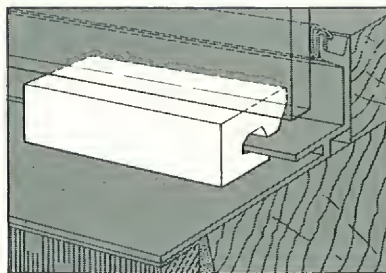
Presenting Pittco De Luxe Hooded Awning Bar No. 60 with ornamental end cap. This bar gives operating mechanism and awning roll adequate protection from the weather. It is designed to harmonize with other shapes of the De Luxe line.

PITTCO Store Front Metal, which has been created by Pittco Store Front Division engineers and designers, is manufactured in the Pittco Division factory at Kokomo, Indiana. It is described in Section G of this Manual.

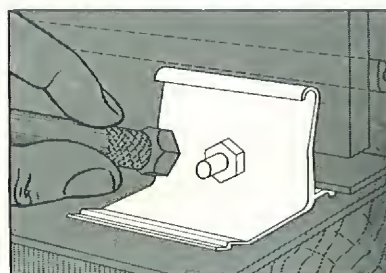
There is an extruded Pittco De Luxe shape for practically every architectural or decorative need which might arise in connection with store front work. The lines are sharp, clean cut and clear in texture and color. The walls are sufficiently thick



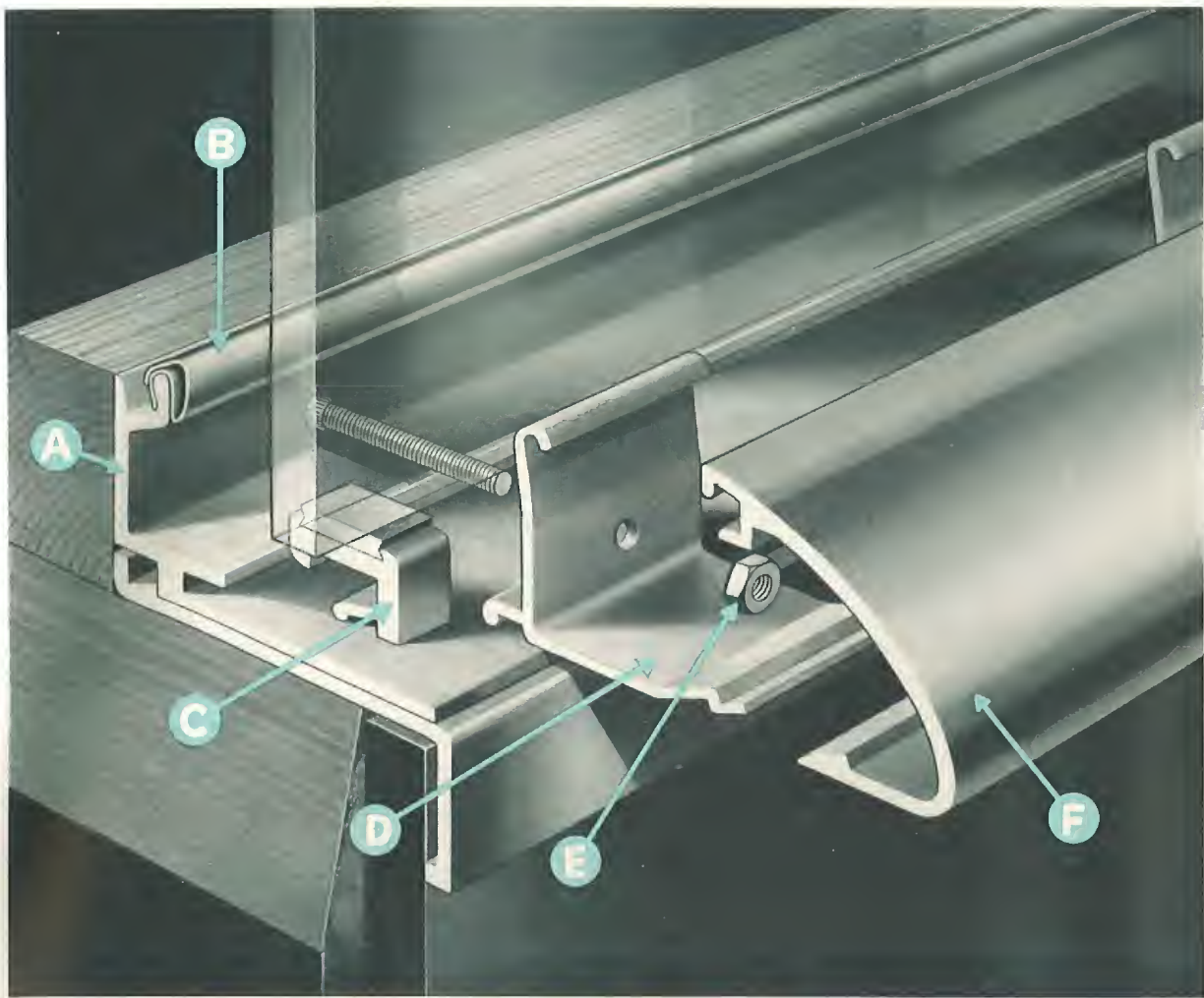
A-B Cushion grip on Glass: The metal which contacts the sides of glass acts as a yielding cushion, absorbing damaging shocks and jars.



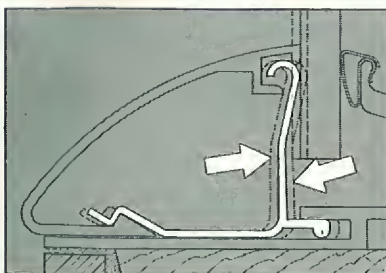
C Fixed supporting block: Non-ferrous setting blocks with lead pads, securely wedged in groove, preventing tipping, rocking and sliding out of line.



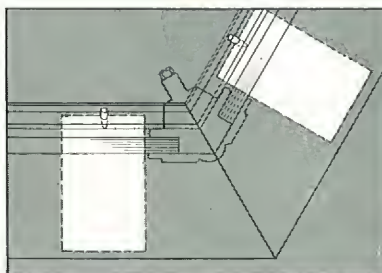
D-E Installation operations all from outside: Both sash and glass are set from outside by standard screws and nuts. No special tools required.



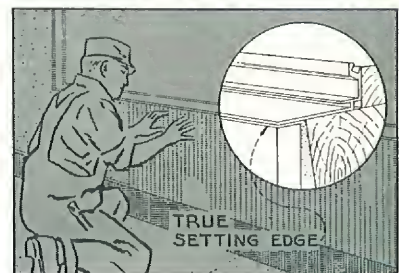
This composite illustration of Pittco De Luxe sash shows the simple process of all-outside installation. Starting from left to right is the inner member (A) with flexible stainless steel cushion (B). Next is the glass resting on secure non-ferrous setting block (C). Then the glass-holding member (D), 1 1/4" wide with holes for standard machine screw, placed 8" on center. This is fixed in position by turning up the nut (E). Finally, the face cover (F) is snapped in place.



F Adjustable to various glass thicknesses: Glass-holding units and face member move inward and outward according to thickness of glass.



Concealed locks secure face and miter without exposed caps. They are especially desirable with Alumilite because of its high coefficient of expansion.



The foremost edge of inner member serves both as a shield and a true line to which Carrara or similar facing materials are set.



Premier sash No. 70 and 1019 sill. This sash is self-adjusting to various glass thicknesses, yet always maintains a firm grip on the glass. All setting operations are done from the outside of the store, a convenience and economy.



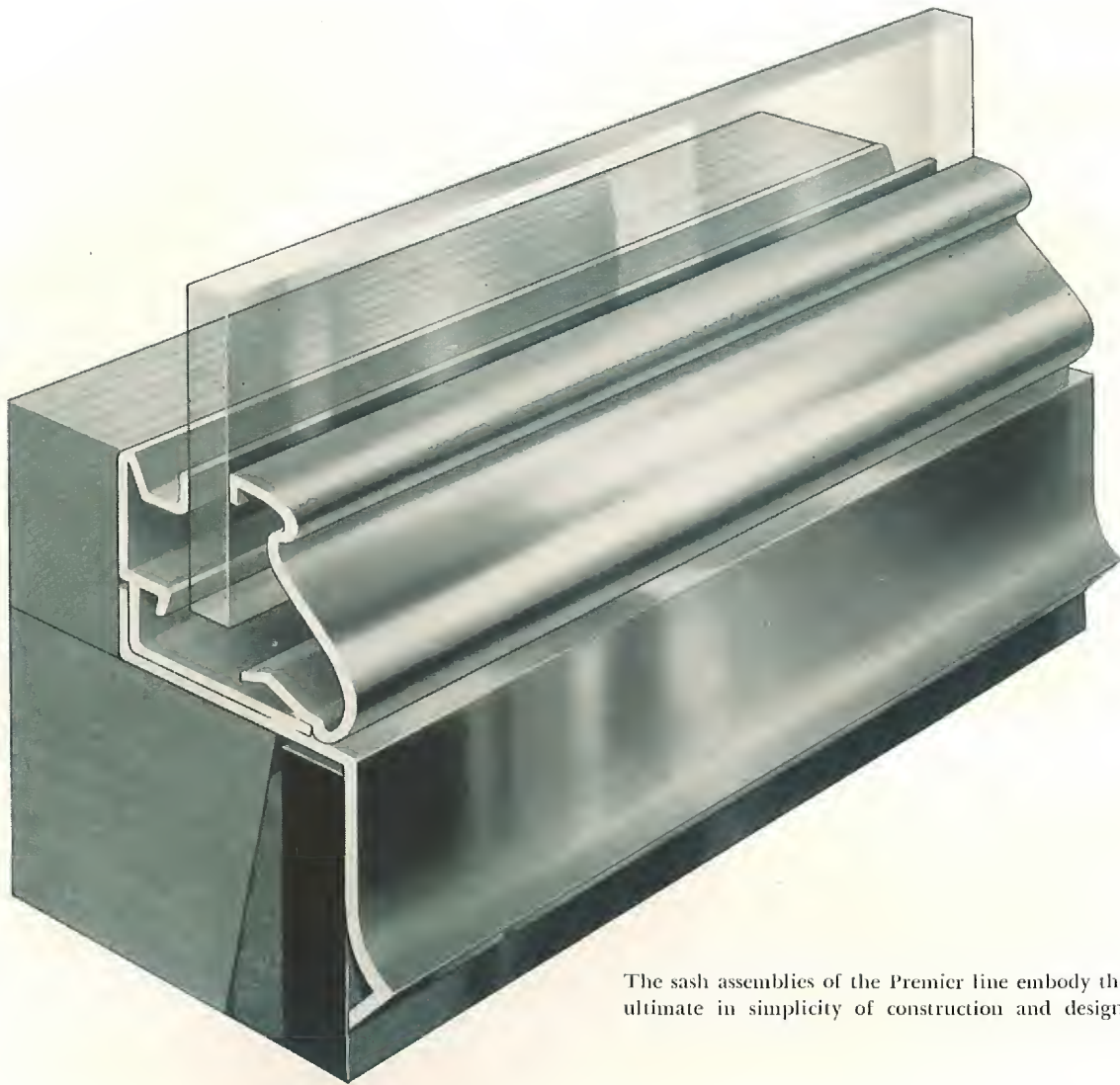
Premier Hooded Awning Bar No. 84 with full end cap. Although lighter in weight than De Luxe, Premier offers plenty of style and punch, plus. The functionability of this bar measures up in every way to the De Luxe type.

to withstand the common abuses to which store front metal is subjected. The pleasing relationship of design found in the Pittco De Luxe line is also present in the Premier group.

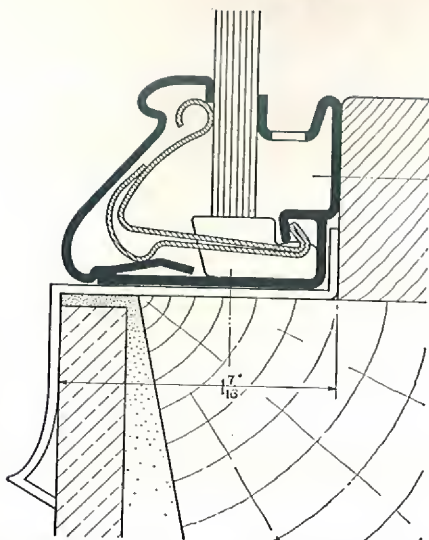
The designing of a store front is a function of the architect who specifies the Pitteo Store Front Metal members and shapes which shall be used in carrying out the particular new design which he has created. Most of these shapes are illustrated here, and details of all of them are available to the architect in the Pittco Catalog or in Sweet's Catalog for Architects. The architect's drawings should comprise details of all materials and construction necessary to the completion of the job, including any modifications of the building structure, new steel work, masonry, Carrara glass facia, plate

glass, etc. The job is regularly let to an established contractor on a regular contract basis and the Company participates only as a subcontractor for the installation of Pittco Store Front Metal, glass and glazing in positions already prepared.

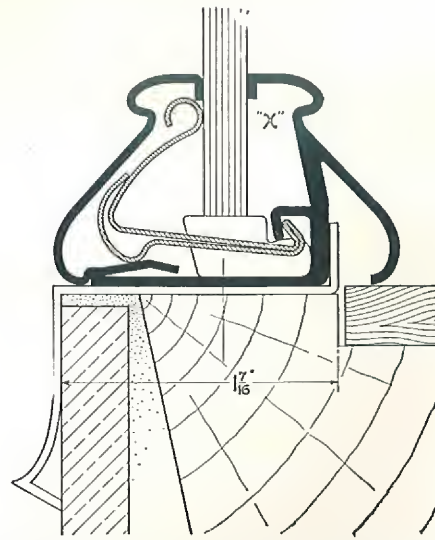
Each of the Company warehouses carries a complete stock of Pittco Metal members, together with the plate glass, Carrara, and other items required to install and produce the complete front in accordance with the plans and specifications prepared by the architect. The actual installation of the Pittco Metal, plate glass, Carrara, and other Company products covered by the terms of the subcontract is made by employees of the warehouse concerned, under the supervision of the warehouse installation department.



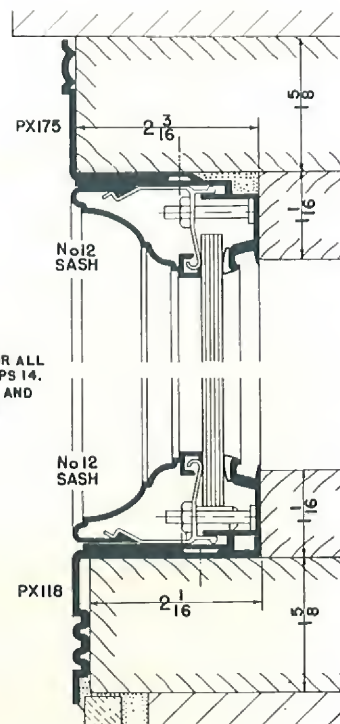
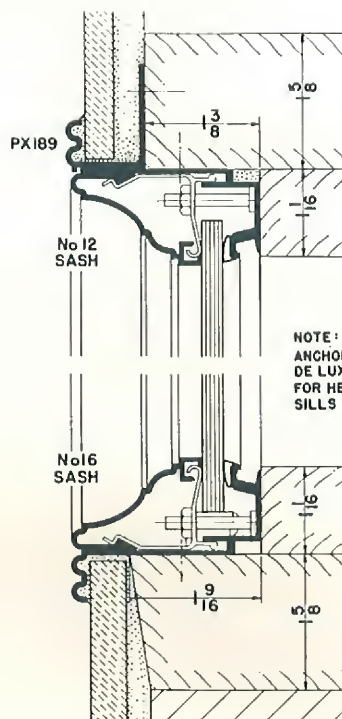
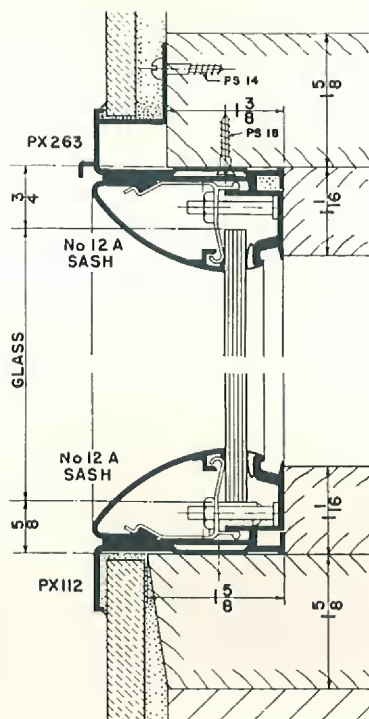
The sash assemblies of the Premier line embody the ultimate in simplicity of construction and design.



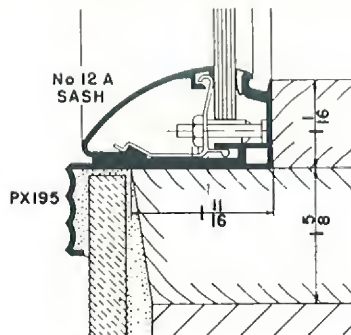
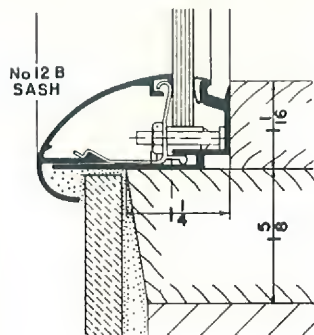
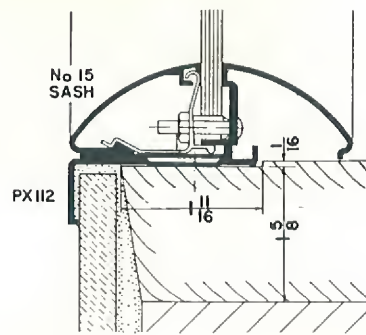
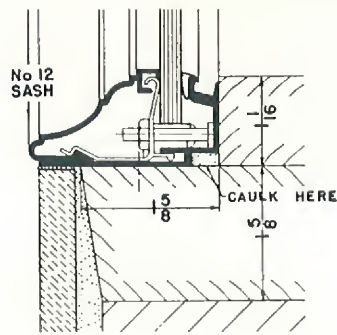
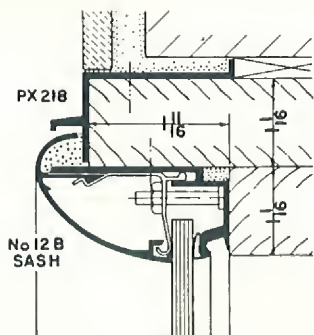
No. 70 Sash: A general purpose sash that can be set from the outside quickly, safely and securely.



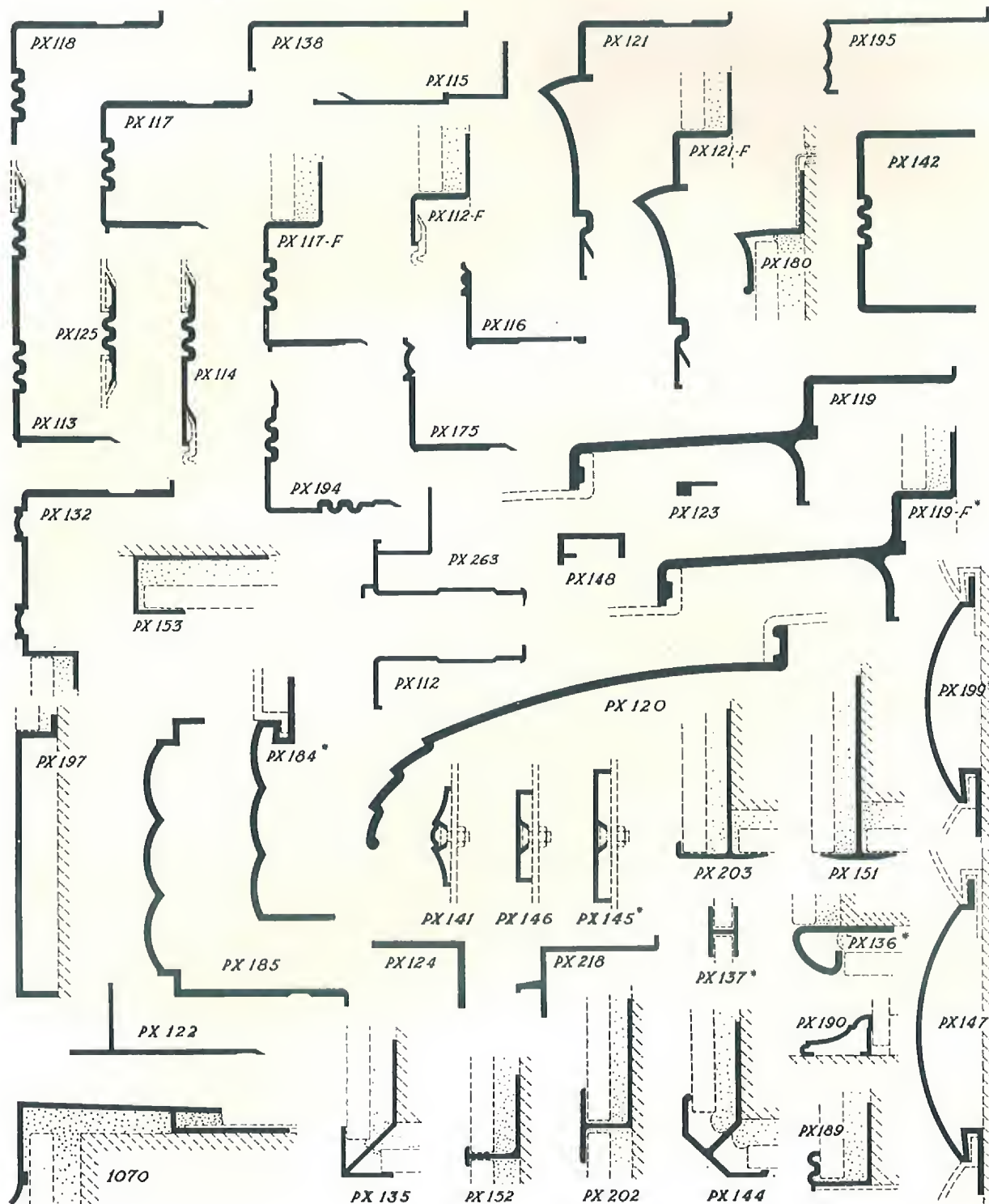
No. 72 Sash: For open display windows, doors and partitions. When reversed for inside setting, use caulking or putty at "X."



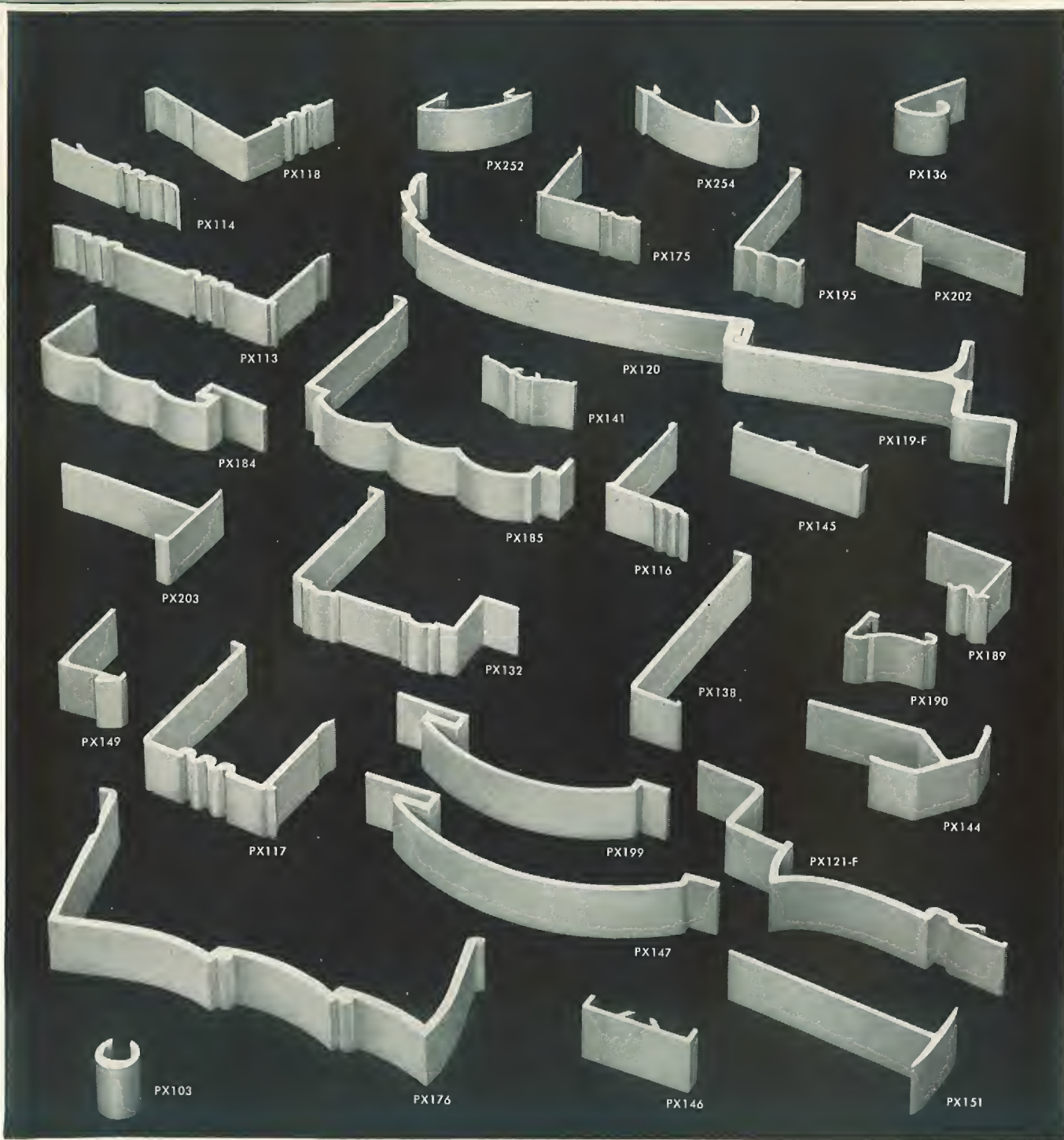
NOTE:
ANCHOR SCREW FOR ALL
DE LUXE SASH IS PS 14.
FOR HEADS, JAMBS AND
SILLS USE PS 18.



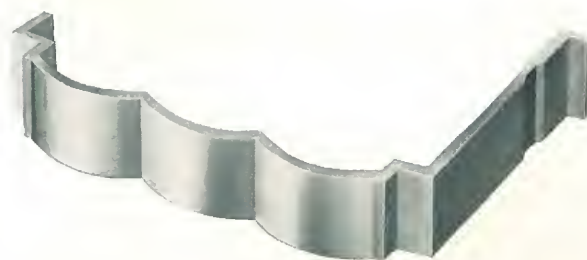
Here is illustrated the complete line of De Luxe sash showing some appropriate sill and head combinations. These units afford the architect great latitude of design.

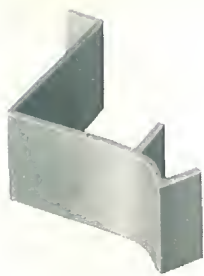
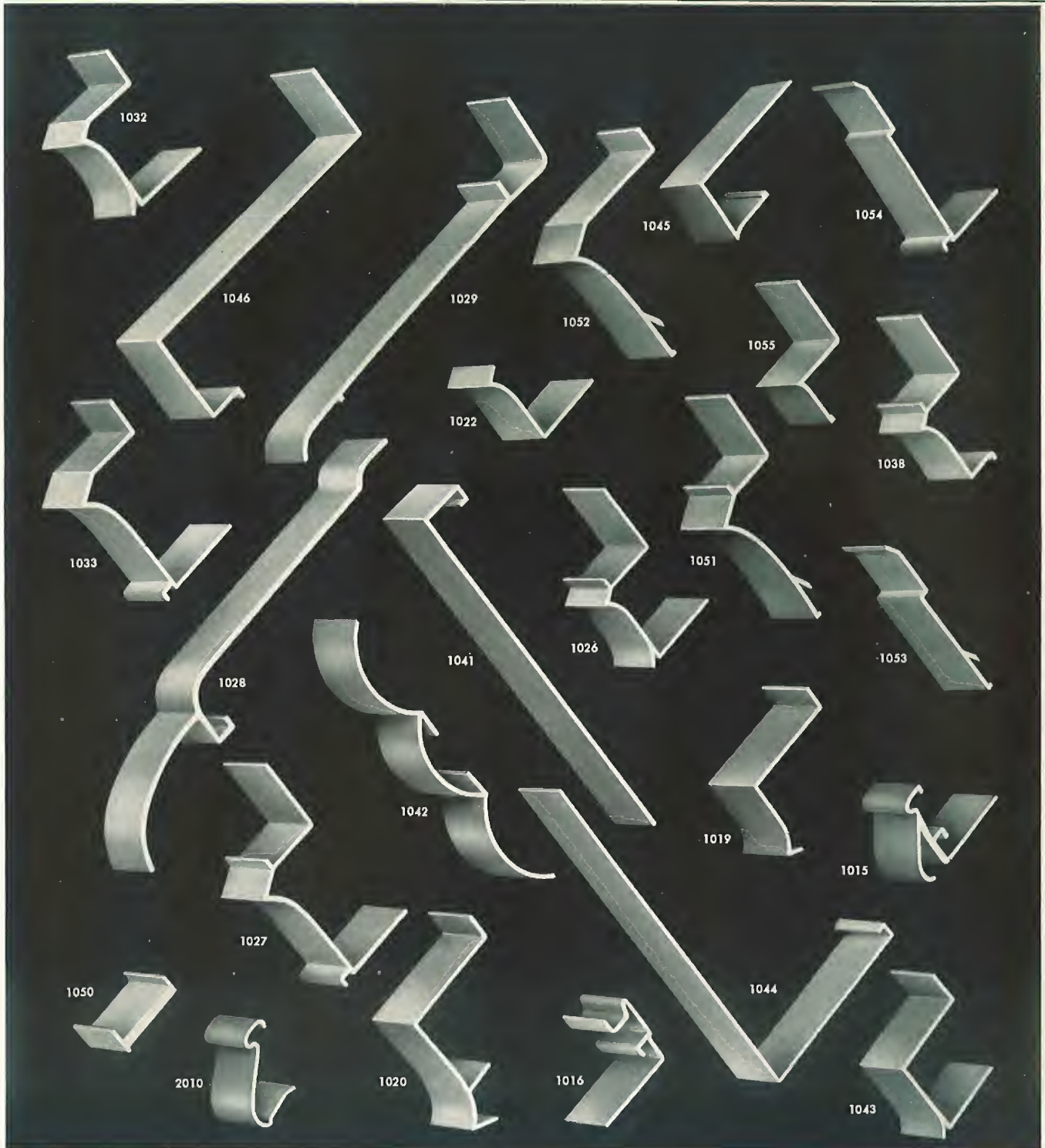


The Pittco De Luxe mouldings illustrated here are carried in stock at the factory and a large number of the Company warehouses.



On this and the opposite page are shown many of the De Luxe and Premier mouldings. It is at once obvious that the range of type and size fills practically every architectural or decorative need that may arise in connection with store front work. The distinguished styling of these mouldings, with their clean contours and graceful lines, and the harmonious relationship they bear to the bars and



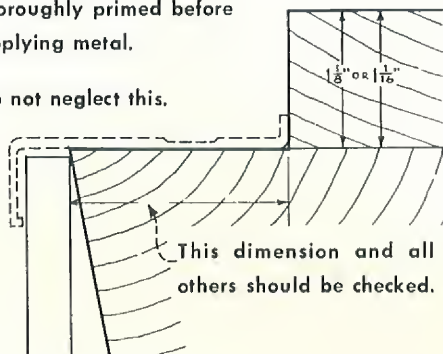


sash which complete the Pittco Metal system, offer the architect and merchant new possibilities in effective store front design. Pittco Metal, when properly used with Carrara, PC glass blocks and Herculite Doors, to say nothing of the many other fine Company products, help to bring the customer's ideas to life, just the way they were pictured in the Architect's drawings.

1 CHECK ALL WOODWORK

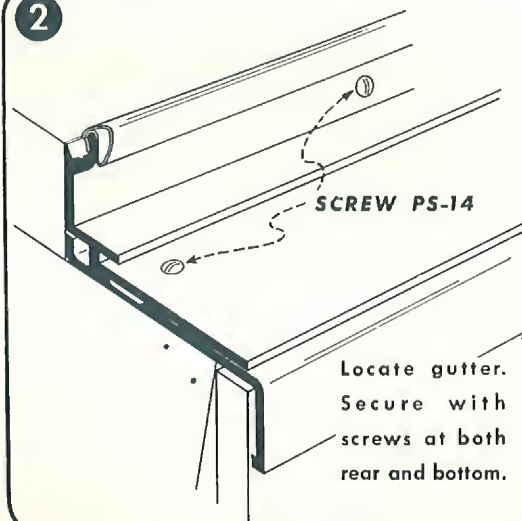
All woodwork should be thoroughly primed before applying metal.

Do not neglect this.



This dimension and all others should be checked.

2



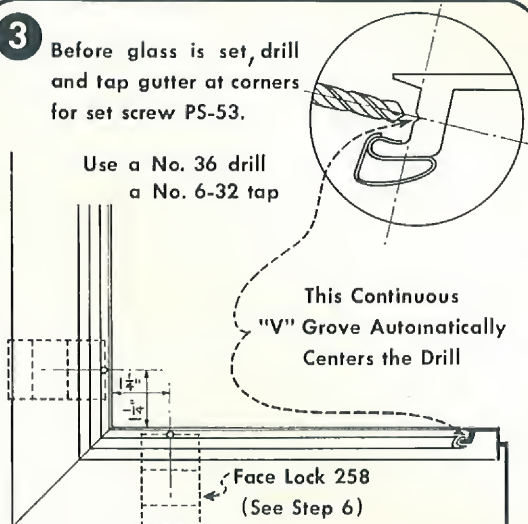
SCREW PS-14

Locate gutter.
Secure with
screws at both
rear and bottom.

3

Before glass is set, drill and tap gutter at corners for set screw PS-53.

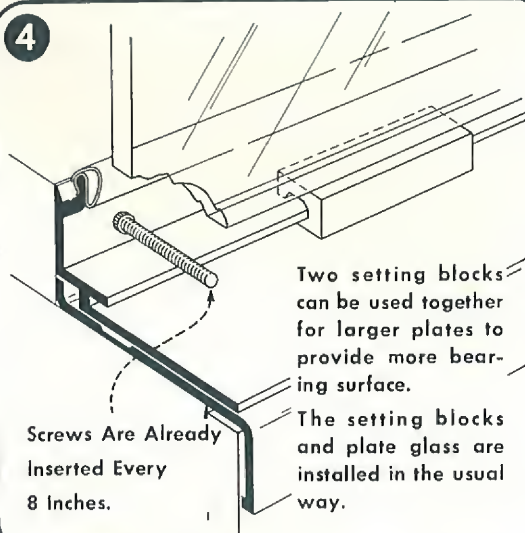
Use a No. 36 drill
a No. 6-32 tap



This Continuous
"V" Groove Automatically
Centers the Drill

Face Lock 258
(See Step 6)

4

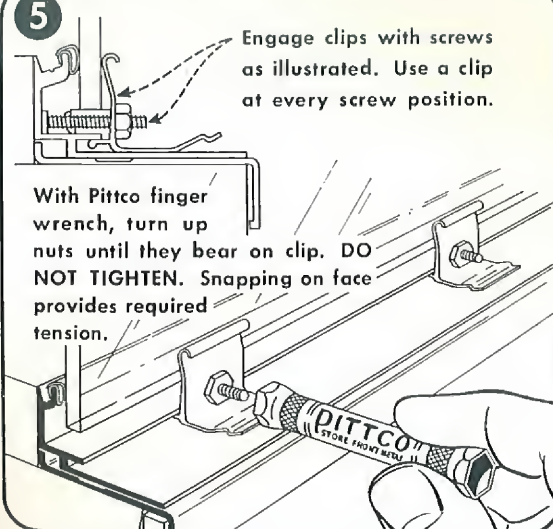


Two setting blocks
can be used together
for larger plates to
provide more bearing
surface.

Screws Are Already
Inserted Every
8 Inches.

The setting blocks
and plate glass are
installed in the usual
way.

5



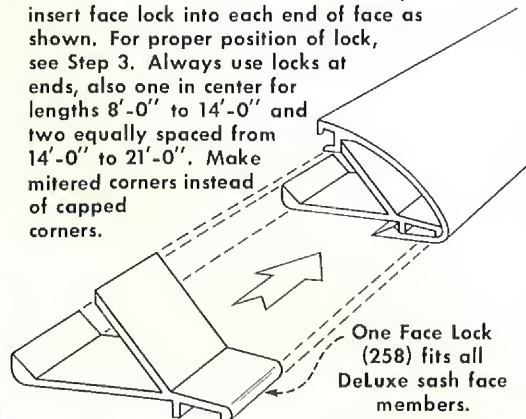
Engage clips with screws
as illustrated. Use a clip
at every screw position.

With Pittco finger
wrench, turn up
nuts until they bear on clip. DO
NOT TIGHTEN. Snapping on face
provides required
tension.

6

INSTALLING FACE LOCK

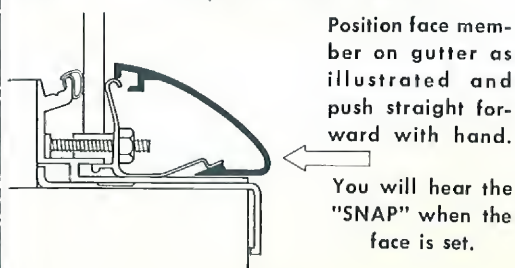
After face members are mitered to fit, then insert face lock into each end of face as shown. For proper position of lock, see Step 3. Always use locks at ends, also one in center for lengths 8'-0" to 14'-0" and two equally spaced from 14'-0" to 21'-0". Make mitered corners instead of capped corners.



One Face Lock
(258) fits all
DeLuxe sash face
members.

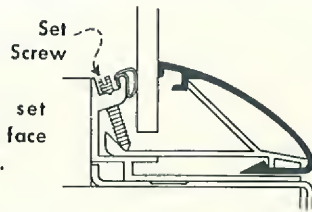
7

ATTACHING FACE



then

Tighten down set screws to secure face locks in position.



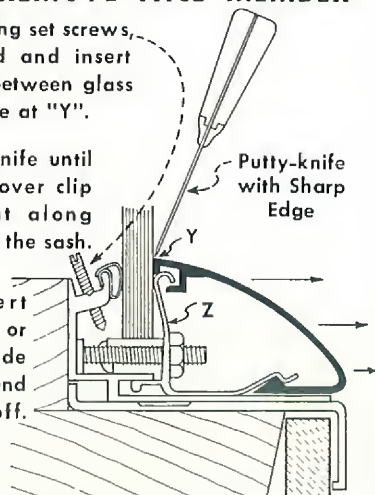
8

TO REMOVE FACE MEMBER

After loosening set screws, start at end and insert putty-knife between glass and sash face at "Y".

Then twist knife until face snaps over clip "Z." Repeat along full length of the sash.

Now insert screwdriver or finger inside of face at end and pull off.



9

INSTALLATION OF CURVED SASH

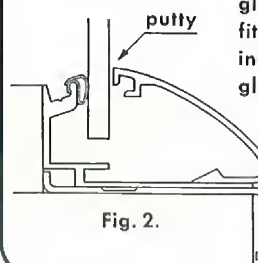
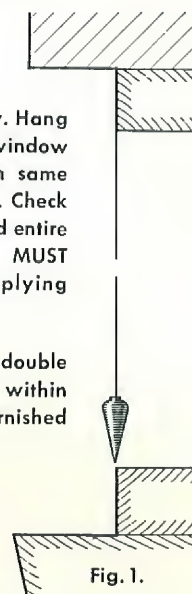
1. Check woodwork carefully. Hang plumb-bob from top of window to see if it lines up with same point at bottom. See Fig. 1. Check curvature every 6" around entire curve. Any discrepancies **MUST BE** corrected before applying metal.

2. The bent metal has been double checked for accuracy and is within 1/32" of the templates furnished by your warehouse.

3. Do not spring or bend metal. Do not drop metal.

4. For best results, clips should be located and set just as they were at the factory. Take a small piece of face and test each lug. Loosen or tighten lug screws until a smooth, snap fit is obtained.

5. The glass, having been bent to a duplicate template, should accurately match the curvature of the metal. Do not attempt to force the glass and metal to a tight fit. Fill with putty any openings which occur between glass and metal. See Fig. 2.



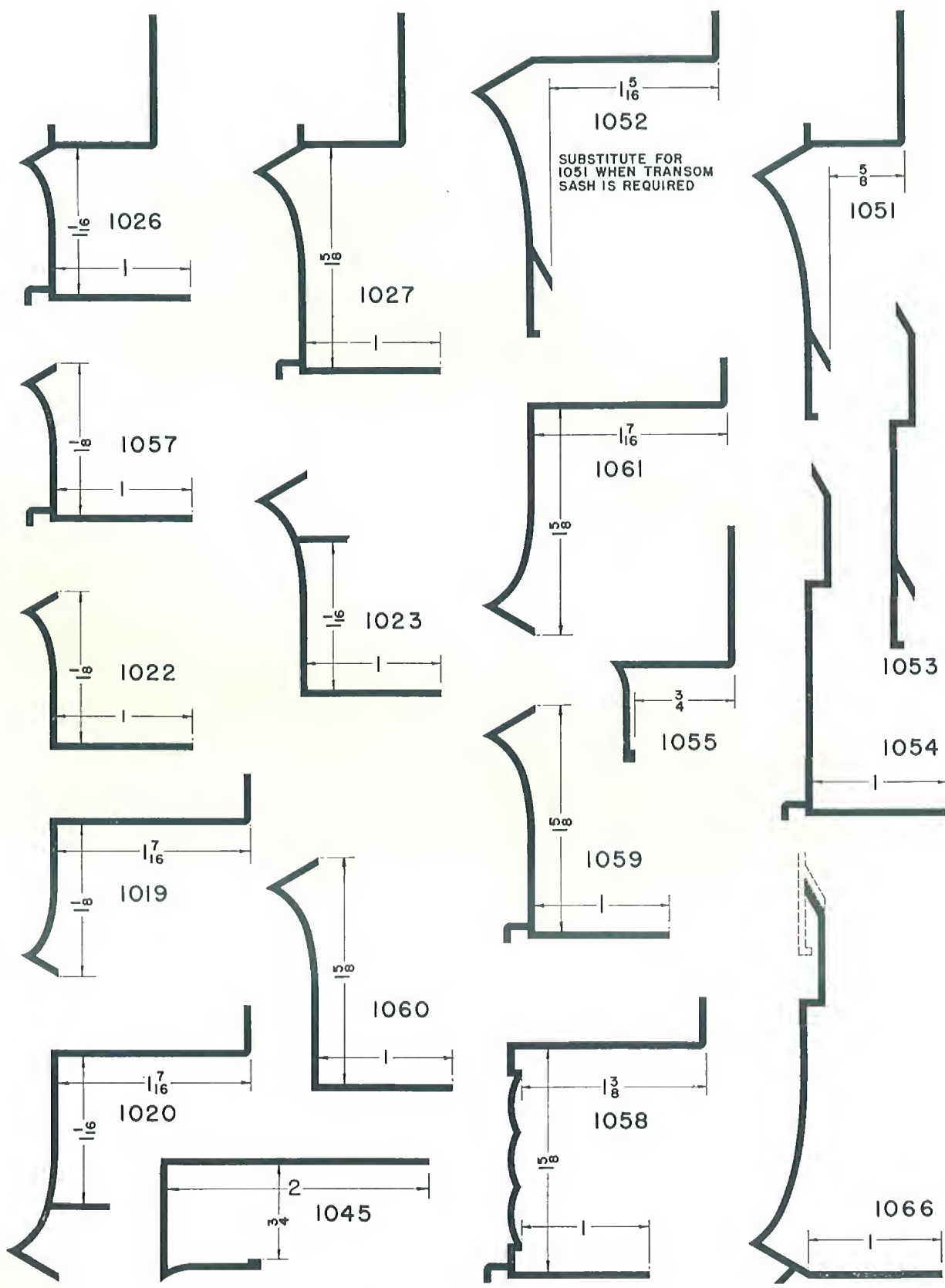
SOME USEFUL TIPS

The setting of Pittco De Luxe sash does not require force. If operations are not smooth and free, do not force. Investigate cause. You will find something has not been done according to instructions.

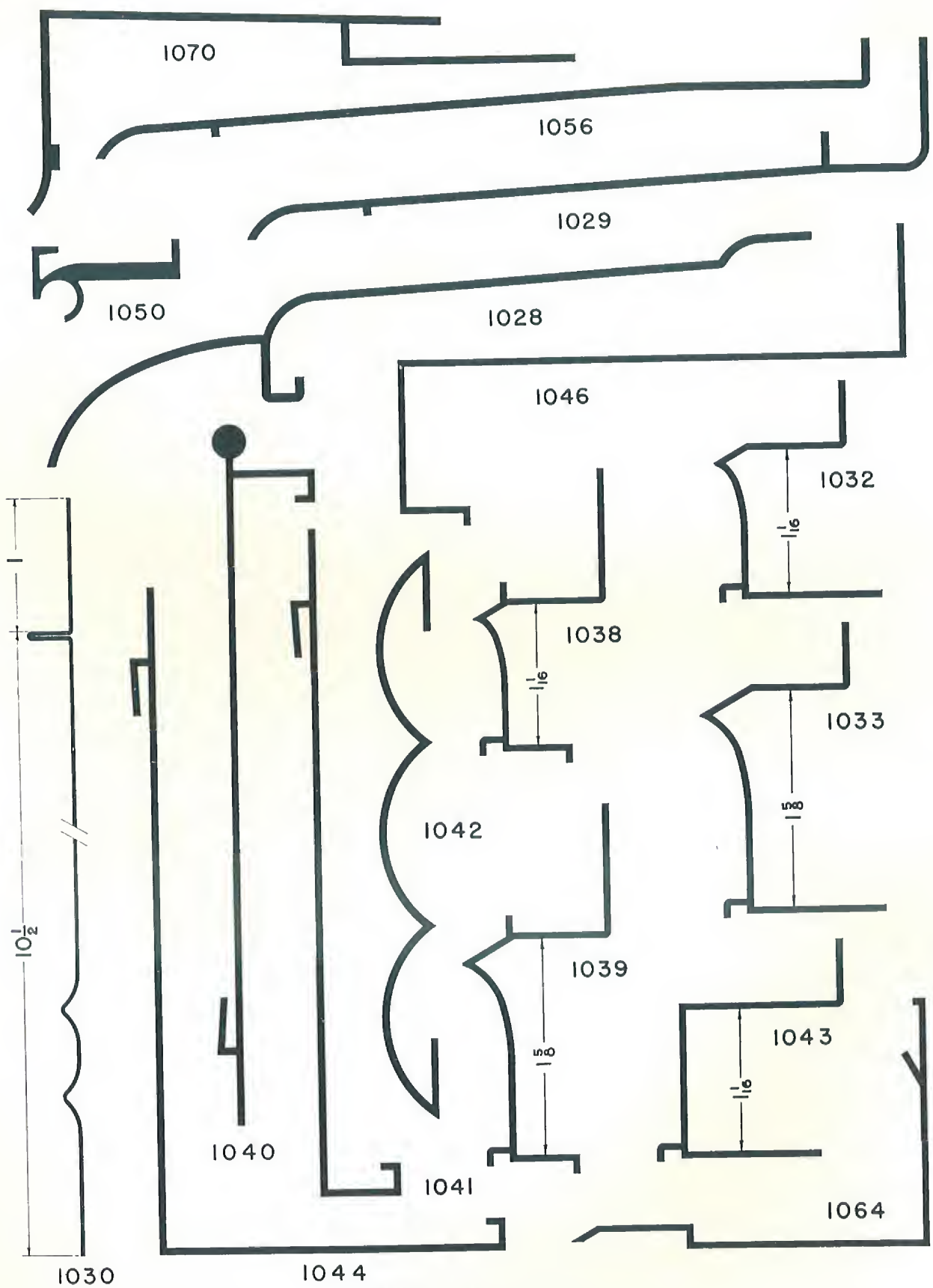
See that sash face is tight against glass before leaving job.

Pittco De Luxe sash look best with neatly mitered corners and no caps.

PROCEDURE IN SETTING PITTCO DE LUXE SASH

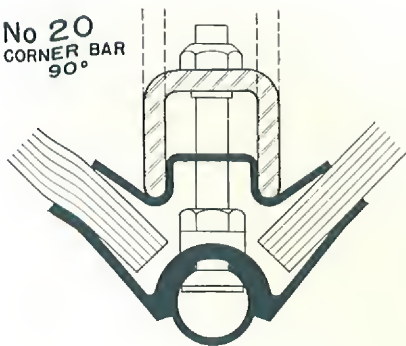


PREMIER MOULDINGS

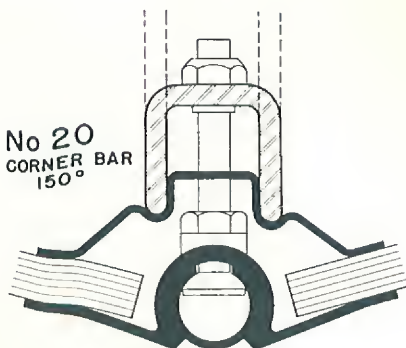


PREMIER MOULDINGS

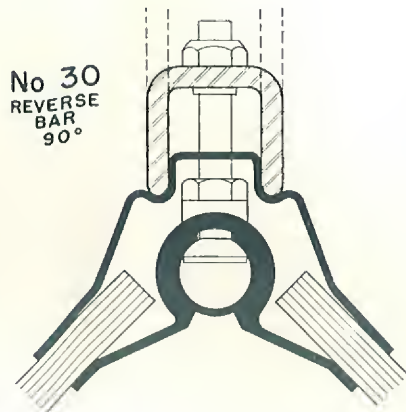
No 20
CORNER BAR
90°



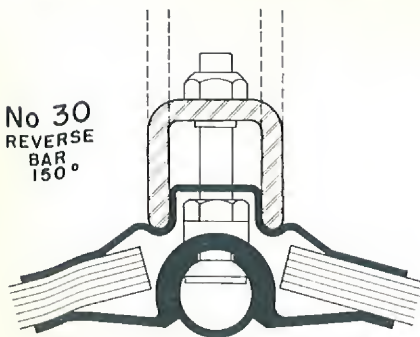
No 20
CORNER BAR
150°



No 30
REVERSE
BAR
90°



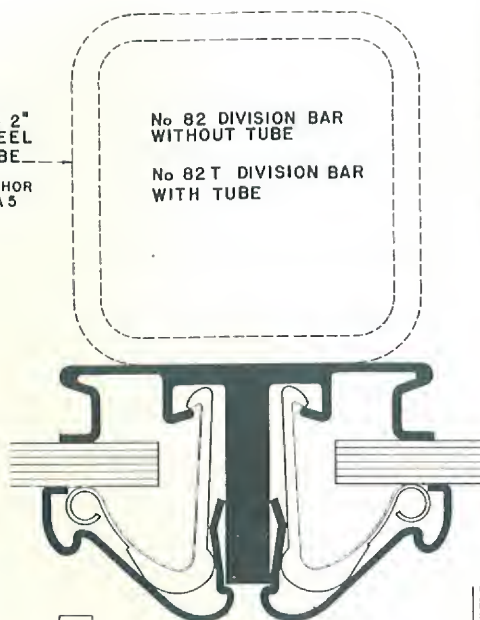
No 30
REVERSE
BAR
150°



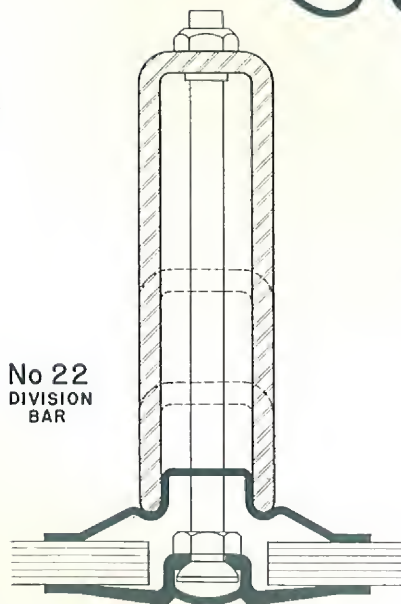
2" x 2"
STEEL
TUBE
ANCHOR
PA 5

No 82 DIVISION BAR
WITHOUT TUBE

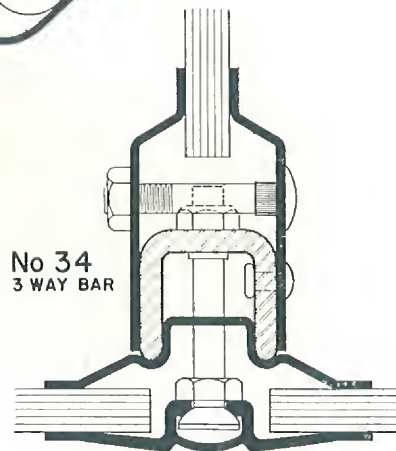
No 82 T DIVISION BAR
WITH TUBE



No 22
DIVISION
BAR



No 34
3 WAY BAR



ALUMILITE
CASING

"XH"
WITHOUT
STEEL CORE

"XHS"
WITH
STEEL CORE

ANCHOR
PA 4

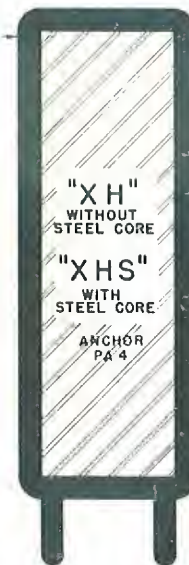
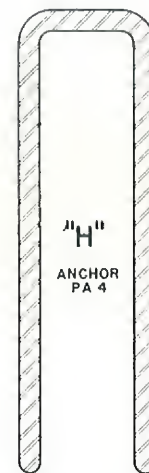
"H"
ANCHOR
PA 4

"L"

ANCHOR
PA 3

"M"

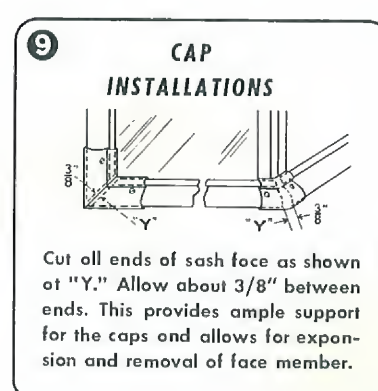
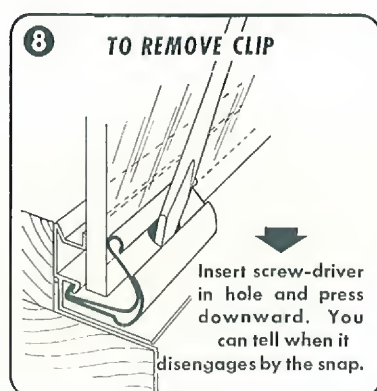
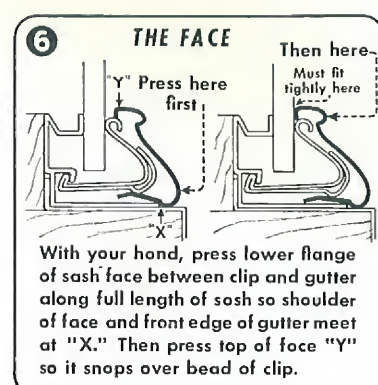
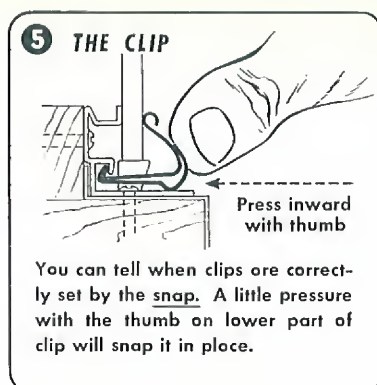
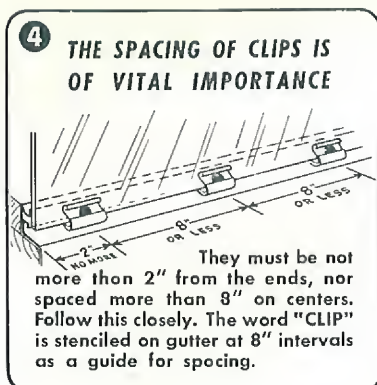
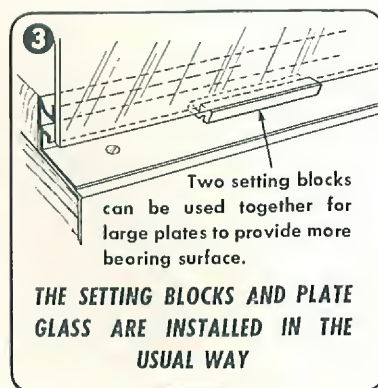
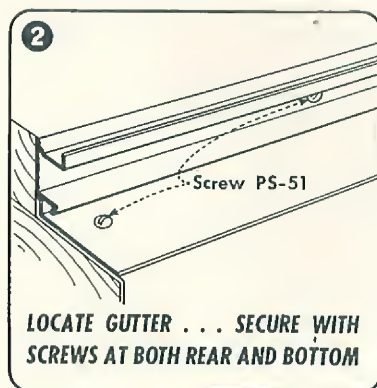
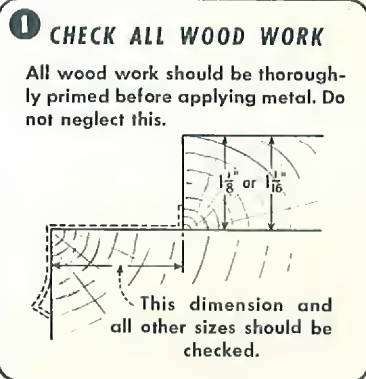
ANCHOR
PA 3



BAR REINFORCEMENTS — SPECIFY BY LETTER

PITTCO BARS

NOTE:
CORNER AND REVERSE
BARS ARE MADE IN AN-
GLES FROM 90° TO 175°.
SUITABLE ANCHORS ARE
AVAILABLE FOR ALL
BARS.
THE USE OF FRICTION
TAPE OVER FULL CON-
CEALED EDGE OF GLASS
IS RECOMMENDED FOR
ALL VERTICAL BARS.



SOME USEFUL TIPS

The setting and removal of clips and sash face do not require force. If operations are not smooth and free, do not force. Investigate cause. You will find something has not been done according to instructions.

See that sash face is tight against glass before leaving job.

Sash face caps are recommended for Nos. 70 and 72 sash installations.

The sequence for setting Pitco Premier Sash No. 70.

Carrara Structural Glass Installation

CARRARA Structural Glass is easy to install. It is handled similarly to marble and may be installed over any hard, firm wall surface. It is bonded permanently to the wall by means of a plastic cement which allows for settling, shrinkage and expansion. A space of $\frac{3}{8}$ inch behind the glass should be allowed to provide for the plastic cement setting.

All hardware necessary for the erection of Carrara Structural Glass or Carrara Structural Glass Prefabricated Units is provided. The glass slabs, or elements, are drilled to accommodate necessary hardware and fixtures. When full information is furnished concerning the location and dimensions of hardware or fixtures procured from other sources such as hinges, strikes, etc., so that the work may be done at the factory, the necessary drilling will be accomplished.

This same provision applies also to any necessary cutting or drilling of Carrara for other contractors on the job.

PREPARATION AND BACKGROUND

Structural glass is usually set against a previously prepared background by means of a plastic cement that adheres to both glass and background by means of suction.

The background must be rigid and securely fastened so it will not move after it is supporting the weight of the glass.

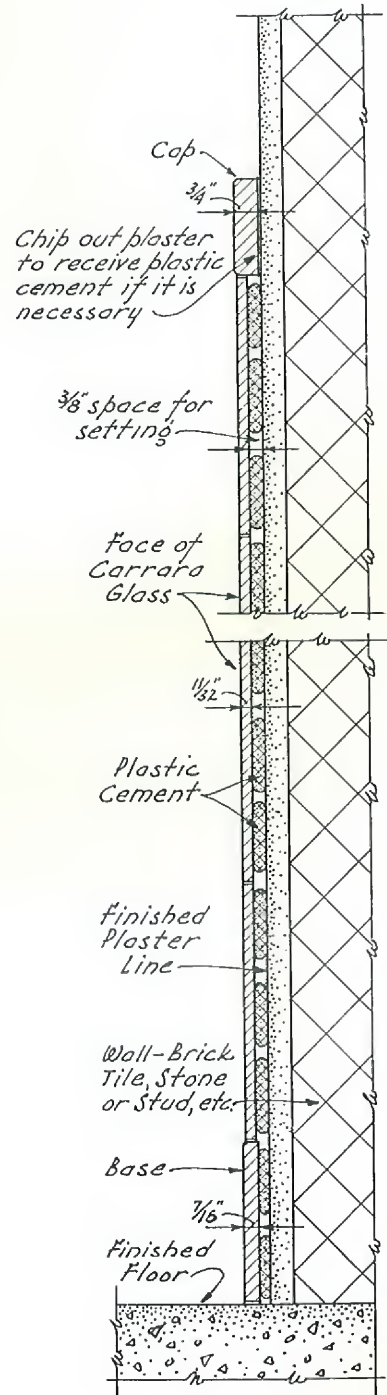
Obviously, masonry of almost any kind meets these conditions and is an ideal backing for structural glass.

If conditions are such that masonry cannot be used, the next best thing is to have the contractor or owner install a backing constructed of metal lath, securely nailed, over which a heavy coat of cement plaster has been applied. A background of wood is not desirable, and every effort should be made to avoid its use.

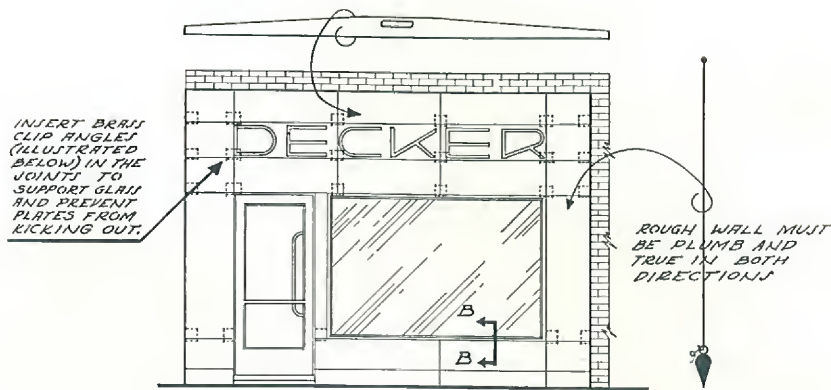
Where glass must be set against wood, it is imperative that first-class seasoned lumber be used. It must be well-nailed, braced and studs should be set closer than is common practice. All woodwork should be thoroughly painted on both sides to prevent absorption of moisture, and swelling and contraction with changes in weather conditions.

Since the cement used for setting holds by suction, it is possible to make a satisfactory installation over almost any material that will remain rigid and presents a firm surface to which the cement may be applied. One background that deserves special mention, and one against which glass is frequently set, is finished plaster. This is encountered chiefly in remodeling work, and the plaster should always be examined to see that it is sound and in good condition.

It sometimes happens that the finish coat has separated from the rough coat, but is still in place. If this condition is present, the entire surface should be hacked with a hatchet so as to remove all the loose plaster.

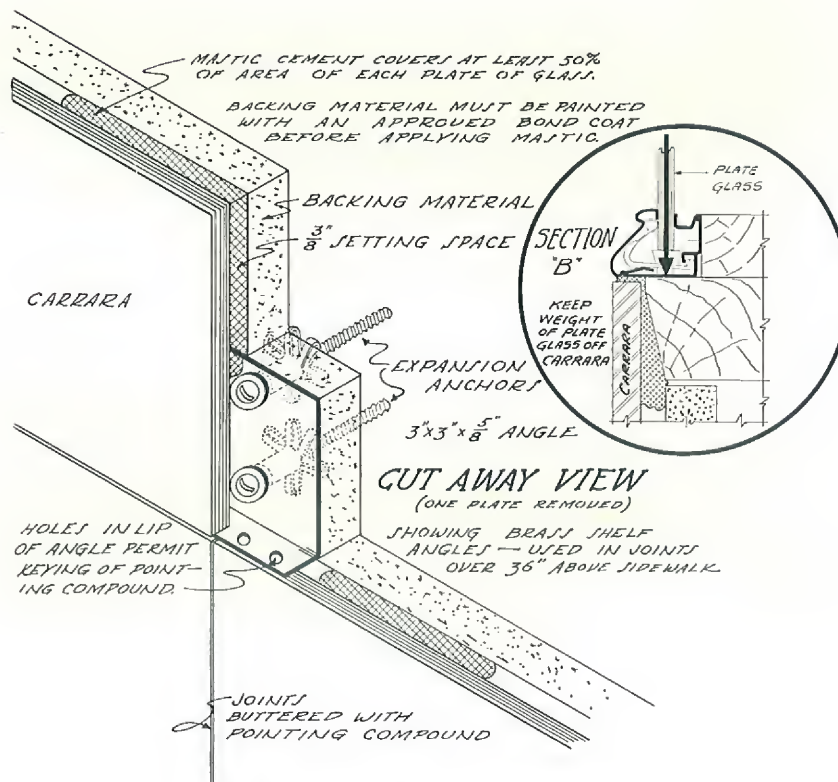


SECTION THROUGH WAINSCOT



USEFUL DIMENSIONS

WITH $\frac{11}{32}$ " CARRARA — FINISH FACE TO ROUGH WORK — $\frac{3}{4}$ "
 WITH $\frac{7}{16}$ " CARRARA — FINISH FACE TO ROUGH WORK — $\frac{3}{4}$ "
 WITH $\frac{3}{4}$ " CARRARA — FINISH FACE TO ROUGH WORK — $1\frac{1}{8}$ "



STORE FRONT BULKHEAD DETAILS

Regardless of the type of background used, it will be time well spent to be certain that the workmen erect it plumb and true. Many hours will be saved in setting of the glass, plus a better result.

BOND COAT

The entire background must be painted with a bond coat before actual setting is commenced. There are two purposes in doing this. First, the surface of the background is sealed

so that the oils and solvents used in the manufacture of the mastic cement are not absorbed, thereby devitalizing the cement and destroying its adhesive qualities.

Secondly, on certain types of backgrounds it is necessary that the bond coat impregnate the surface particles, binding them together so that they do not pull loose with the mastic which is later applied. Examples of this type of background are soft plaster, or certain types of concrete where there is danger of applying the cement against a film of dust which would immediately pull loose, or another example would be



USE OF WATER LEVEL TUBE

time, but is a plastic material having definite desirable characteristics. It must be plastic enough to allow the workman to shove the plates into place, and then toughen enough, within a comparatively short space of time, to prevent the plates being moved thereafter.

It must have adhesive qualities, high tensile strength and preferably should be light in weight.

It must contain materials that will not oxidize, dry out, or allow it to become brittle, but must be able to withstand high summer temperatures without softening.

The volume shrinkage must be low, and it must be composed of materials which will not change or deteriorate over almost an indefinite period of time.

For these reasons the cement used should be one which has been tested and has the recommendation of the structural glass manufacturer.

Since mastic cement holds by suction, it makes very little difference what type of back is on the structural material. Probably better adhesion will be obtained on a smooth back. It is very important to remember that mastic cement has very little strength in shear, i.e., it cannot be depended upon to prevent glass from slipping even though it requires a direct pull as high as 60 pounds to the square inch to move it from the surface of glass or wall. In view of this, it can readily be understood that each piece of glass must be supported on the bottom edge either by another piece of glass or by other mechanical means.

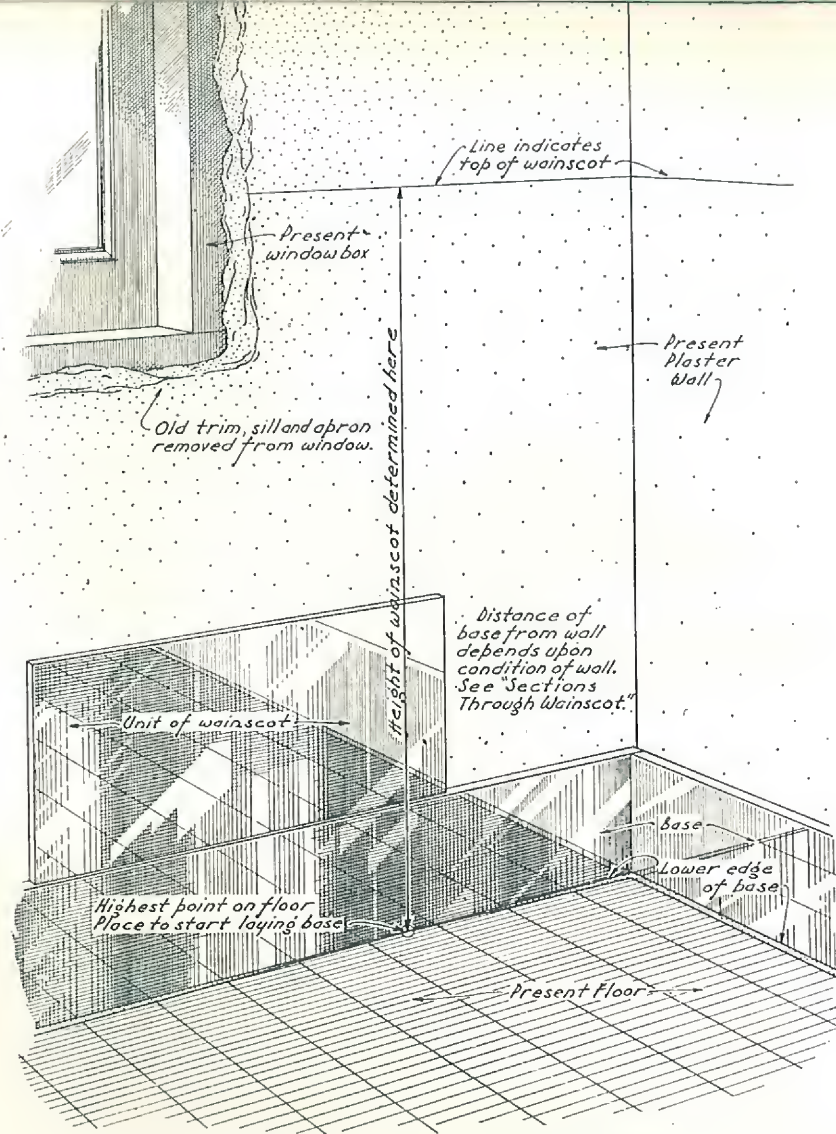
GENERAL INSTRUCTIONS FOR SETTING

The cardinal principle back of all successful setting is that structural glass must be set free from strain or the possibility of strain due to subsequent changes or movement in the building.

Breakage is almost invariably the result of a conscious or unconscious violation of this principle.

The easiest way to snap a piece of glass is to bind one edge rigidly, and then try to bend it by moving the other edge. This is exactly what happens, for example, if a plate of glass is set with the lower edge running into a cement or terrazzo floor, and the upper edges move ever so slightly due to shrinkage or settling of the building. There are innumerable ways in which glass may be constrained while setting, so make it a rule always to allow clearance around fixtures, or at points where glass joins other materials. At points where setting glass into masonry cannot be avoided, make certain that a strip of softening material is inserted between the glass and the masonry. A free-standing shower partition with the rear edges running into a masonry wall will remain in good condition indefinitely if the setter has placed a strip of ordinary roofing paper on each side of it to prevent the bricklayer or tile setter from grouting Portland cement tight against the glass.

A piece of glass, when properly set, should be held by the



DETERMINING HEIGHT OF WAINSCOT

mastic and nothing else, except for the support along the bottom edge to prevent slipping.

Study the placing of the joints because it is through them that flexibility of the installation is obtained.

For example, a wainscot or store front bulkhead formed of single panels from top to bottom has flexibility only in a horizontal direction. The simple expedient of placing a base below the panels provides a horizontal joint permitting flexibility in a vertical direction also.

AVOID GLASS TO GLASS JOINTS

A glass to glass joint should never be allowed under any circumstances. Before the plates are set, butter the edges with an approved type of pointing compound, or if this is not available, zinc white ground-in-oil will make a very good substitute.

If the pointing compound is omitted, the slightest movement of the glass will cause the edges to spall or chip and the pressure from expansion will cause vents or small cracks that will eventually extend across the entire plate.

All drilling and cutting should be done as neatly and cleanly as possible. This is too often considered unimportant, which is not the case.

Roughly chopped holes, edges badly nipped or hacked down to a line with a lag screw, all contain hundreds of vents any one of which may later open up into a crack. Usually, in the finished job all the rough work is concealed

and later, if a break occurs, the cause of the damage may be puzzling until the plate is removed.

TOOLS

It goes without saying that a full complement of tools and a knowledge of their use is necessary if installation is to be accomplished easily and in a workmanlike manner.

A first-class workman's bag will contain the following tools, most of which are essential.

Glass cutters	Electric Mastic Dispenser
Two hammers—one regular one 1-ounce size	Small trowel
Brace	Chalk line
Assortment of drills	Plumb bob
18 or 24 inch square	Bench brush
18 inch level	2 clamps
48 inch level	25 or 50 foot water level
Chisels	Pair dividers
Small pinch bar	Miter square
Carborundum stone—grits	Small wrench
No. 40-60 and 100	Rubber mallet
Pair of glass nippers	6 foot rule
Pair of tongs for heavy glass	50 foot tape
Putty knives, one small and one large	Hack saw
	Scraper
	Rubber suction cup

Several of the tools in the list deserve special mention—the use of the others is obvious.

The 48 inch level will be found handy as a combination straightedge and level, and much more accurate than a small one in checking stretches of base or ashlar.

The assortment of chisels should include a wood chisel for cutting studs where they interfere with recessed accessories, or for cutting other woodwork that hinders setting of Carrara.

The pinch bar will be found valuable for ripping off old wood trim, opening cases or for prying when leveling heavy glass partitions.

Small glass nippers are used on Carrara $\frac{3}{16}$ inch or lighter to nip an edge back to a line previously made by a glass cutter. The tongs perform the same service on heavier glass, but require more experience in handling. Either will work better if the jaws grip the glass through a heavy piece of cloth.

The electric mastic dispenser provides a convenient device for ladling out the correct proportion of mastic to form one gob or pat. It is electrically heated to permit ease of working.

A bench brush is used continually to keep the work table free of chips, and to clean the floor before base is set.

There is nothing that will satisfactorily replace several screw clamps when it is necessary to brace temporarily a large shower partition or other free-standing pieces of glass. They will permit fastening wooden braces to the glass. Clamps will also be found useful for holding chalk line.

The use or value of a tube water level is not as well known as it should be, and for this reason has been illustrated. With this type of level, elevations may be transferred quite a distance with ease around corners and to places hard to reach with a straightedge. A great number of points may be established in a few moments. The usual length is 50 feet, but may be longer.

A small adjustable 6 inch wrench is carried by many setters to use in nipping glass instead of using regular nippers. An advantage of the wrench is that it can be used inside a notch or hole where it would be awkward to use nippers.

A rubber mallet will prove useful for bringing a piece of base or glass back to line, but of course it must be used with discretion.

One or two suction cups should be in the workman's bag because it is only by means of these that a plate can be pulled out from the wall if it has been pressed in too far.

SETTING

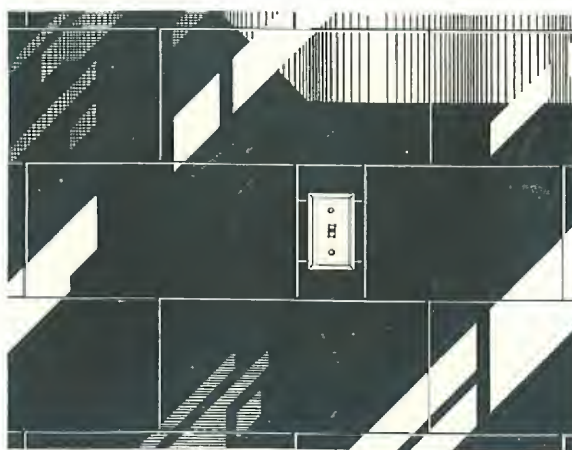
Let us follow through the setting of a typical bathroom or kitchen:

A good workman will first check over the drawing or sketch, if there is one, so as to become thoroughly familiar with the job and know where all the different pieces belong.

Unpack the glass, or that portion which will be needed first, and stand it on edge in a safe place with strips of paper or cardboard between the plates to prevent scratching. Check the quantities of Carrara and list of accessories at this time to avoid discovering, just before ready to leave the job, that something is missing or incorrect in size. The very necessary operation of painting the wall with bond coat will not be overlooked, and pains will be taken not to soil woodwork or other materials. It is exceedingly difficult for the painter to enamel or paint over wood and plaster that has been smeared or spotted with asphaltum-type bond coat.

CHECK FLOOR LEVEL

The next step is to determine the condition of the room, first testing the floor to determine whether or not it is level,



JOINTING AT ACCESSORIES

and locate the highest spot adjacent to the wall. This is then the starting point for vertical measurements to keep the top edge level the entire way around the room. If the setter inadvertently chose the low spot to commence setting the base, the first high spot encountered would raise it, or it would be necessary to resort to the expensive and difficult operation of trimming the lower edge to fit the floor.

The top edge of the base must be exactly level, because if it is not, the setting of the balance of the glass will be a most disheartening job, and the result will be unsatisfactory.

When setting is commenced at the high point, it will make little difference if the lower edge of the base is $\frac{1}{8}$, $\frac{3}{16}$ or even $\frac{1}{4}$ inch above the floor. When the opening is filled with pointing the same color of the base, it will not be noticed and, in many cases, it will be covered with the finished floor covering.

CHECK WALL PLUMB

Before setting the first piece of glass, check the wall to ascertain just how far it is out of plumb, because this will determine how far from the wall to set the base.

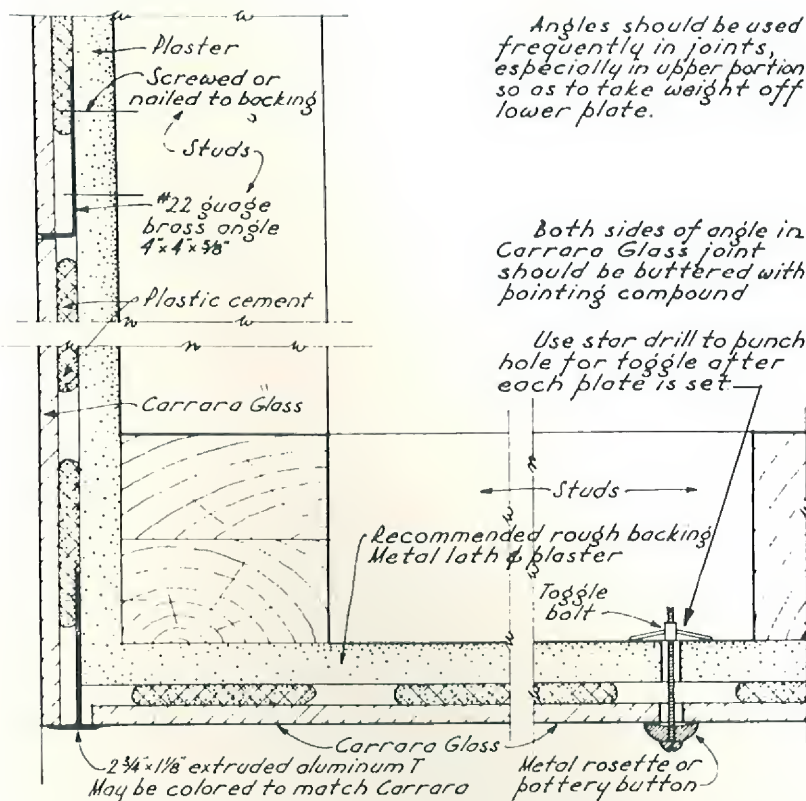
If the wall leans away, the base is set as close to it as possible, even chopping out depressions in the plaster to hold the spots of mastic if necessary. The closer the base is set, the nearer the cap will be to the finished plaster at the top of wainscot. If the wall leans in, drop a plumb line from a point which is the top of the ashlar or wainscot. The simplest way is to hold the line out from the wall by a $\frac{3}{4}$ inch block of wood so that the spot located on the floor represents the face of the wainscoting.

If the base is to be flush, it will then be set this distance from the wall, or if it has a projection, it will be moved out from the spot established by the plumb line, the amount of that projection.

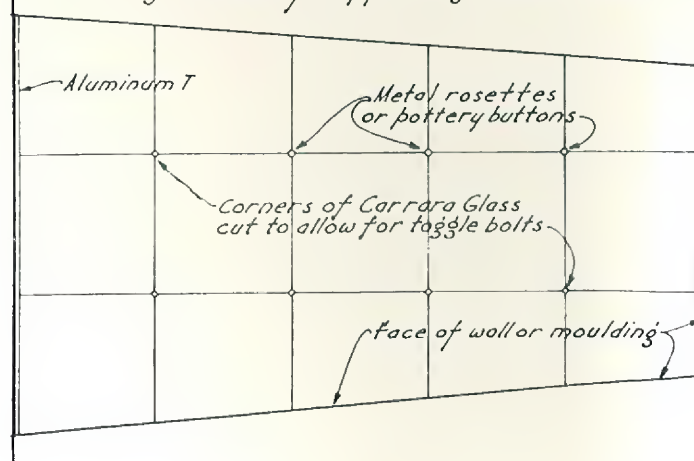
After the base has been set level, and in perfectly straight lines, the ashlar plates or panels are set above it, taking care to keep them plumb and straight—testing with plumb, level, and straightedge.

A good setter will prepare for setting by making a small table out of scrap lumber or secure a substantial box, placing over this a piece of old carpet or other soft material to prevent scratching the glass while applying the mastic.

Lay the glass face downward on the table so that the mastic may be applied to the back by means of the electric mastic dispenser. The mastic is dipped out of the can in gobs and applied to the glass every 5 or 6 inches in suffi-



SECTION THROUGH STOREFRONT FACIA AND ENTRANCE CEILING.
Showing method of supporting Carrara Glass.



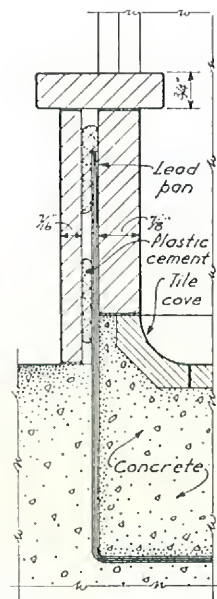
DETAILS

cient amount to make the spots 1 inch to 1½ inches high, and so that there will be a coverage of approximately 40 per cent after it is flattened out against the wall.

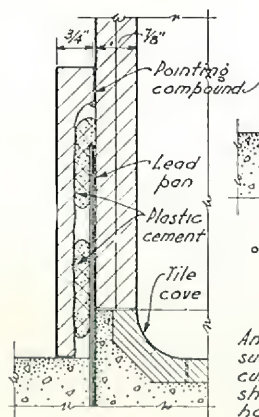
Considerable difficulty will be avoided if the spots of mastic are not placed at the extreme edge of the plates, because it will not get into the joints and bleed through the

pointing compound and discolor it. For the same reason the edges should be kept clean.

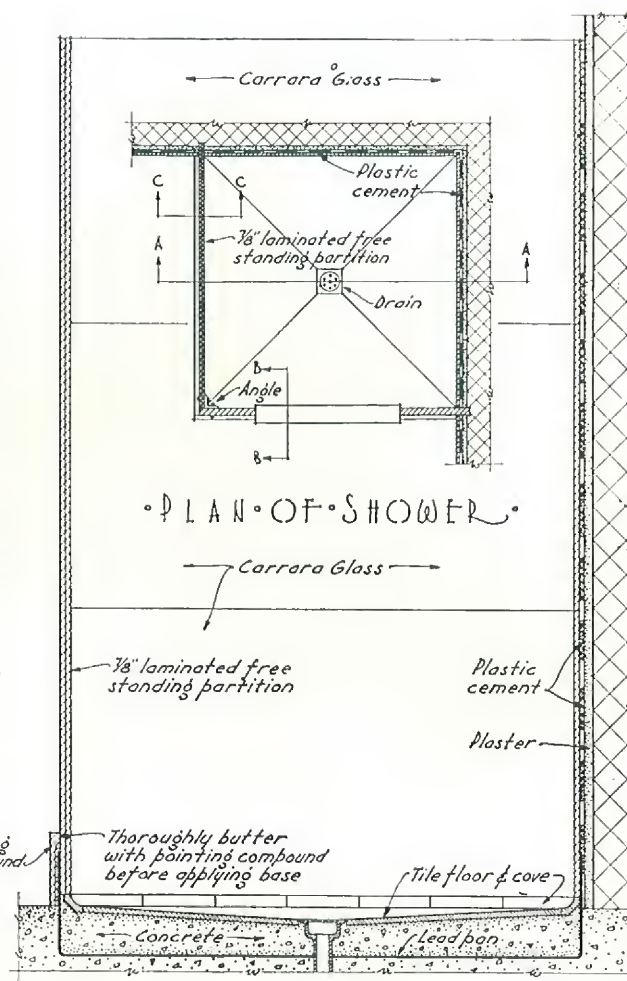
Before a plate is set, the edges must be buttered with pointing compound so that there will be no glass to glass contact. The compound may be applied to either the glass in place, or to the plate about to be set.



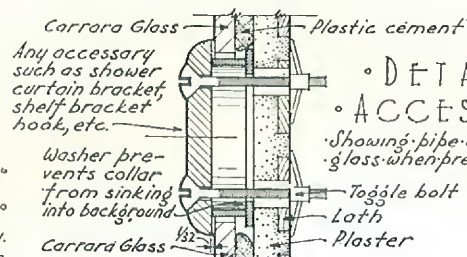
• DETAIL OF
• SHOWER CURB
• SECTION B-B
• Showing lead pan.



• DETAIL OF BASE
• SECTION C-C
• Showing sand-blasted
• rabbit at back of base.



• SECTION A-A THROUGH SHOWER



• DETAIL AT
• ACCESSORIES
• Showing pipe collar to protect
• glass when pressure is applied.

DETAILS OF SHOWER

WORK PLATES INTO POSITION

After the mastic and pointing compound are placed, bring the plate against the wall, starting it slightly above and to one side of where it is to be set, so that it may be forced back and into place with a rubbing motion which greatly assists in getting good adhesion of the mastic.

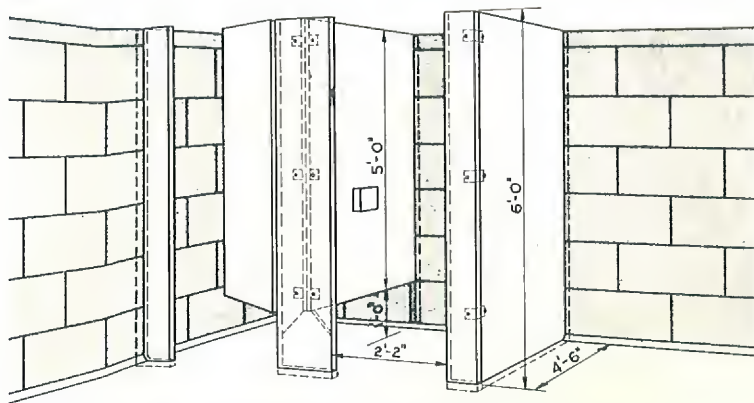
Before the walls are up too far, lay out the location of the fixtures such as soap dishes, towel bars, etc.

A little thought and care here will save a great deal of cutting and fitting and will do much for the appearance of the job.

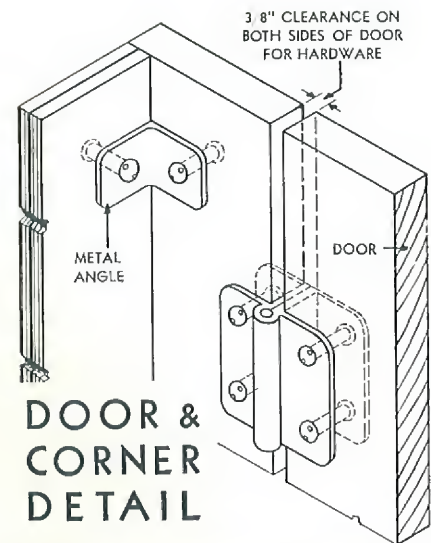
If accessories of the flange type are used, it is only neces-

sary to leave the rough openings until completion of the job, when they all may be set at one time. If the accessories are of the type that finish flush with the face of the glass, it will be necessary to set them as the work progresses, because the glass must be cut and neatly jointed around them.

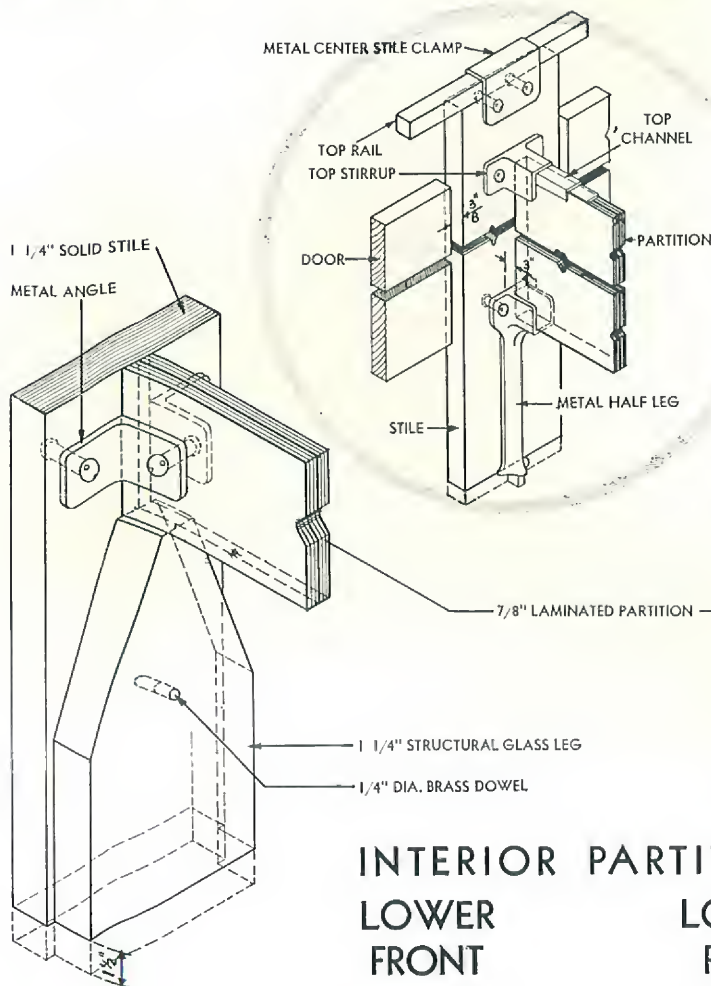
Porcelain accessories, before setting, are first soaked in water, and then set by means of ordinary plaster of Paris. The fixture is buttered with plaster on the back and the depression in back of the glass is also lined with it. The fixture is then pressed into place and held there until the plaster sets. The usual method of holding them in place is by means of a stick run to the floor. Nothing elaborate is required, because the plaster sets up in twenty minutes to half an hour.



METROPOLITAN TYPE (MODIFIED)

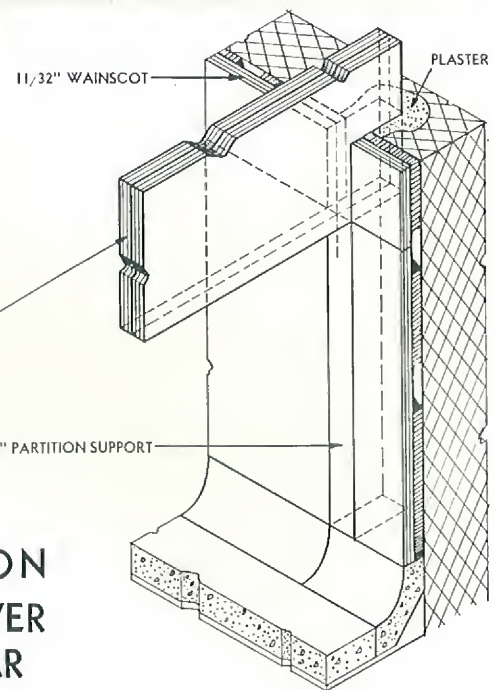


**DOOR & CORNER
DETAIL**



**INTERIOR PARTITION
LOWER
FRONT**

GOVERNMENT TYPE



**LOWER
REAR**

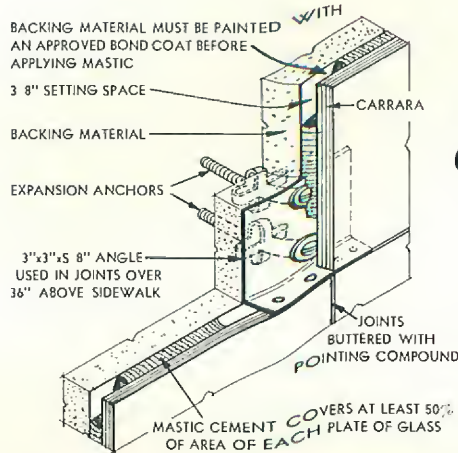
DETAILS OF TOILET STALL

After the wainscoting has been set, other members, such as cap, door trim, window trim, sills, etc., may be set in place easily if care has been exercised in laying out the base, and the walls have been carried up plumb and true.

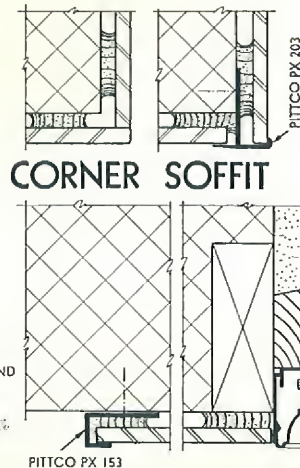
These are important details and their consideration must not be left until the last minute.

A condition around a window, for example, may require the base to be set slightly farther in or out so that the trim will make a neat joint with the jamb and also the wall.

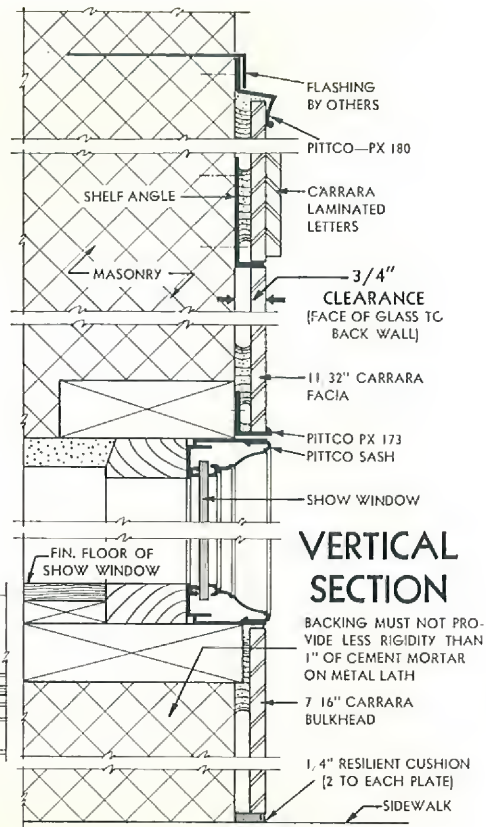
One learns through experience on numerous jobs how to avoid occurrence of certain conditions which add to the cost of setting.



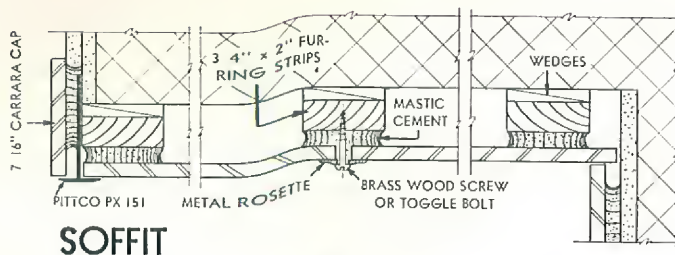
CONCEALED SUPPORT



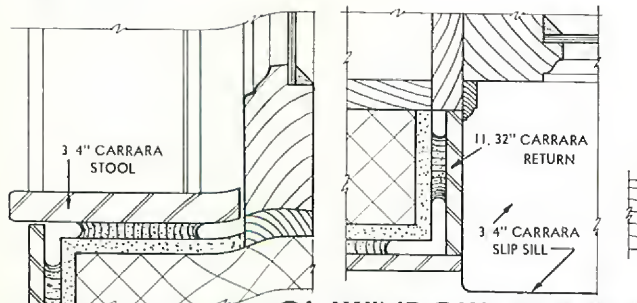
JAMB



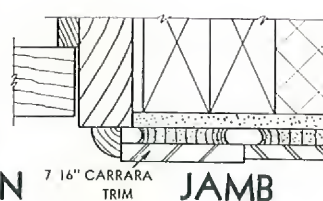
VERTICAL SECTION



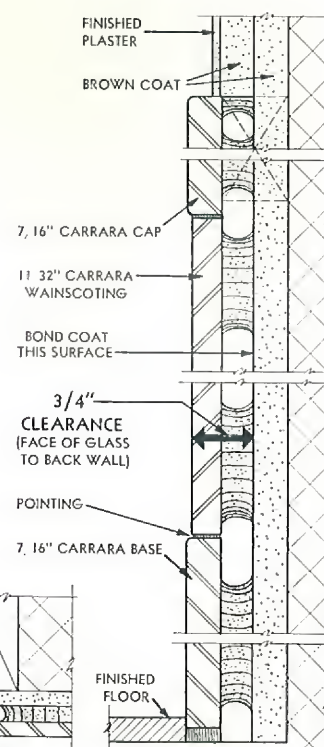
SOFFIT



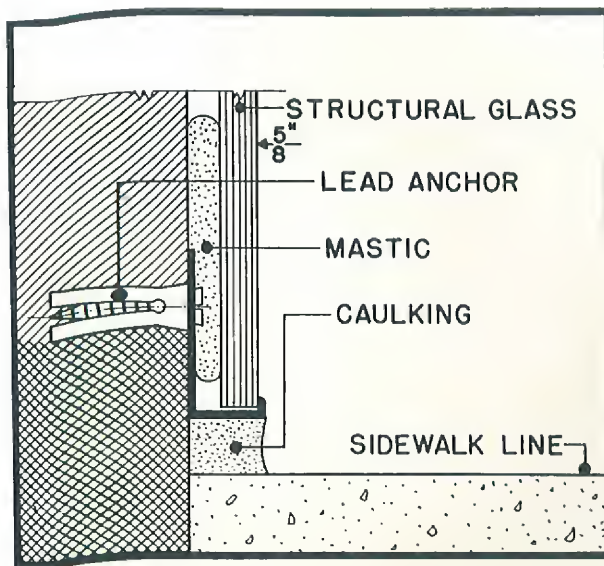
WINDOW STOOL WINDOW RETURN



JAMB



WALL



DETAIL AT SIDEWALK

It will always pay to examine the bathtub and other fixtures for scratches and other defects, and, if found, to report the condition so that at a later date the blame does not fall on the glass setter.

If the work is being done after the finished floor is laid, it is necessary to lay a tarpaulin or protect the floor in another manner. Otherwise, the small chips of glass and dirt will be ground into the floor—permanently marring it. This also applies to interior of tub, window sills, etc.

Much time will be saved if the Carrara can be installed after the finished floor is in place, as well as electric switch outlets, heaters, etc. This avoids interference by other workmen waiting while necessary work preceding the Carrara is finished, and chance of damage to the Carrara after setters have left the job.

EXTERIOR INSTALLATIONS

When setting store fronts or other external installations, the same general conditions as previously outlined hold true.

Be certain that the background is rigid, well-supported, plumb and true.

Apply waterproofing before setting is started, and see that sufficient cement is used—about one pound to a square foot of glass—and hold the setting space to a maximum of $\frac{3}{8}$ inch if possible.

On exterior installations special conditions occur that require consideration. Due to the nature of the design, it is often a temptation to furnish plates too large in area. Ten square feet is an ideal figure to set up as a maximum.

Winter weather makes setting difficult. If there is any choice, avoid setting in extremely cold weather, and, if possible, have the work completely enclosed with a barricade. The temperature inside a barricade can often be raised by heat from the building or from a salamander.

Before applying the mastic, be sure condensation has not left a film of moisture on wall or glass, since this will hinder adhesion of the mastic.

Glass may be wiped dry with a cloth, and a wall may be dried and warmed with a blowtorch.

SOFTENING MASTIC

Never add solvent to mastic to thin it so it will work easily in cold weather. Warm it if necessary, but NEVER over an open flame, which will burn it and destroy its life and adhesive qualities.

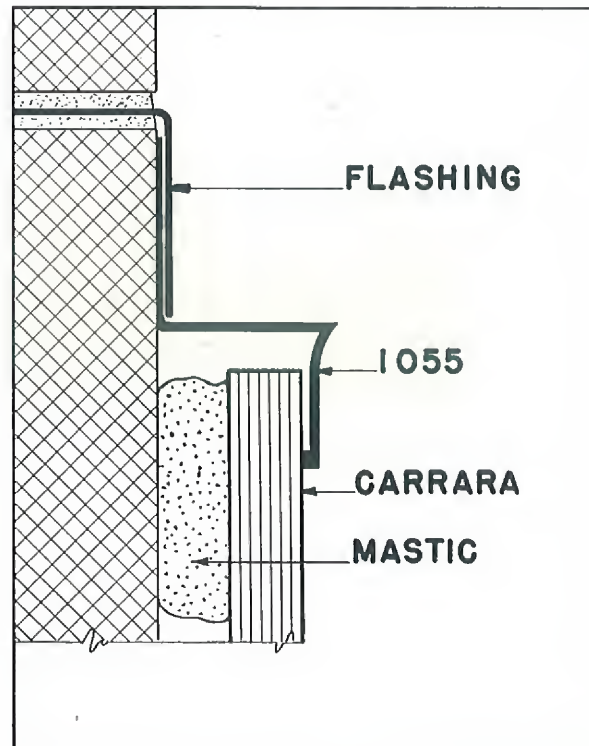
It is often possible to keep it warm by simply storing it in a warm room or near a radiator. Another plan is to partially immerse the can of mastic in a pan of hot water. The water may be kept hot by means of a blowtorch or by the insertion of an electric immersion heater.

No matter how well a job is set, ice and snow will tear it loose, so be certain that there is no point where water can get in back of the glass or collect.

When laying out the work and establishing the joints, odd-shaped pieces should be avoided wherever possible, because expansion is uniform in a rectangular piece, but it is not uniform in an odd-shaped piece.

The thickness to be used depends a great deal on whether or not it is subject to mechanical injury. If this is the case, as on wainscot base or store front bulkheads, $\frac{3}{16}$ inch thickness is probably the most desirable. On store front work above the danger point, it has been found that the thinner glass is satisfactory, so that $\frac{1}{32}$ inch may be used for the upper part of the store front, but of course, when thin glass is used, it is even more important that the plates be kept as small as possible.

There is no necessity for getting the plastic cement any place else than where it belongs, and workmen should be particularly cautioned about marking decorated work or sandblasted work, as this is extremely hard to clean, and in some cases where silver has been used, almost impossible. The common practice is to clean the Carrara with naphtha



DETAIL OF FLASHING

or kerosene oil. However, if too much is used the pointing material will be washed out of the joints.

SCAFFOLDING

Exterior installations quite often run to considerable height so that additional problems are presented. Where scaffolding is necessary, it should be built firmly and as rigidly as possible so that it will not move outward when the workman is applying pressure to bed the glass plates into place.

For this reason, a swinging scaffold is not satisfactory unless arrangements can be made to tie it against the building through the windows or by some other means.

Naturally, height of glass means weight, so on installations rising above one story or ten to twelve feet, it is necessary to support the glass on metal angles inserted in the joints. If angles are not used, the entire weight will be transmitted to the lower plates with the danger of buckling, which may force them away from the wall.

When the angles are inserted in the joints as shown on the illustration, they will also assist in holding the glass on the wall because it requires great force to pull them out of the joints after the pointing compound has hardened.

CARRARA TOILET ROOMS

The procedure for setting structural glass in a small toilet room is not unlike that of a bathroom, except for the precaution that must be taken in setting partitions, stiles and hardware. In the larger jobs there is more routine, and definite steps which should be taken in order to make the installation easily and economically.

The shop drawings of course have been prepared many weeks in advance, have had the architect's approval, and the glass has been got out and numbered according to these drawings.

If the job is not in the same town as the warehouse, it will be necessary to arrange for drayage from the freight office to the job.

Also arrange with the general contractor for use of the hoist on buildings where glass must be set above the first floor. It is essential that an accurate record be kept of the time consumed in using the hoist, since this is usually charged back by the general contractor at a fixed rate per hour.

The glass naturally should be distributed through the building close to the rooms in which it is to be set, and the glass for each room should be opened as it is needed in order to avoid breakage and marring of the glass by other workmen, which often occurs if the glass is unpacked before needed.

BENCH MARKS

The first step in arranging to set the glass is to locate the bench mark or level that has been established by the engineer. This mark is usually located 4 feet above what will eventually be the finished floor. If the job is big enough to have an engineer there permanently, he may establish a 4 foot mark in the various toilet rooms, or if not, transfer this mark by means of the water tube level, and even if the engineer locates one point in the room, the level may be used to transfer the mark to the different walls of the room.

At this time, or even before establishing the level, the bond coat should be applied, so that it has sufficient time to dry before setting actually commences. It is customary to place a chalk line around the room, locating this several inches above the base. This line, and any other dimension can be established by measuring down from the 4 foot mark.

SETTING BASE

The first operation is to set the heavy $\frac{3}{4}$ inch base, which takes the weight of the partitions. It is not sufficient to level this base, but it must be the correct height, so that the bottoms of the partitions are the correct distance above the finished floor. Also it must be the proper height to insure that when the stiles are fastened to the partitions, they will enter the floor the correct distance. In order to be sure of this, it is necessary to check the level of the floor. If the floor dips in the center, it will be necessary to set the base lower than if the floor is entirely level.

After the base has been set and the location of the partitions established, slots should be cut in the rough wall to receive the partitions. A glance at the drawing for the Metropolitan type construction will explain visually, the entry of the partition into the wall. If the construction is the Government type, there will be no need to have the partition enter the wall, since they stand free.

SETTING PARTITIONS

Insert the partitions in the slots in the wall, blocking them up temporarily at the front and aligning them, one with the other, and otherwise fastening them so that they will stand in the final position.

It is extremely important that there be placed on either side of the partition at the back edge, several layers of paper tape, or masking tape, or a strip of roofing paper. This provides a cushion, so that the glass will not be damaged when the wall is plastered, or covered with Portland cement, as is the case when tile wainscot is used with glass partitions.

SETTING STILES

Following the setting of the partitions, wrap the bottom of the stiles with corrugated paper, masking tape, or anything that is soft and pliable for at least 6 inches from the bottom, so as to allow an expansion joint or space between the finished floor and the glass—to prevent breakage. (Note: This protection is very essential, and should never be neglected.) The paper protection can be removed, where it extends above the finished floor, upon completion of the work, by cutting it off with a razor blade.

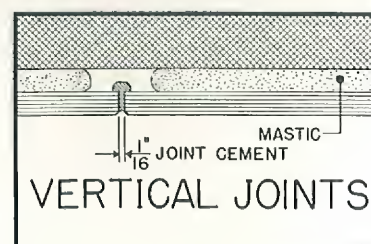
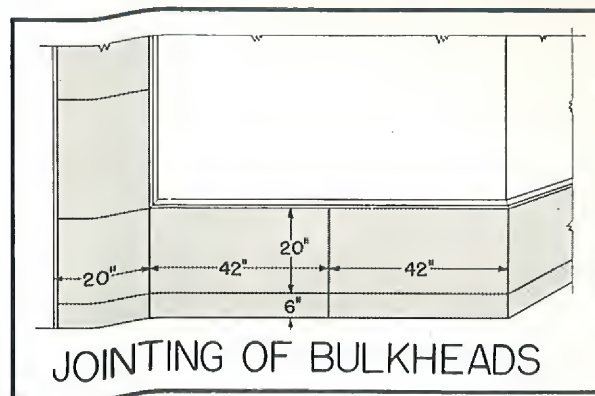
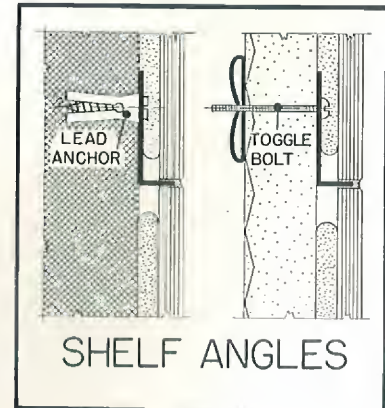
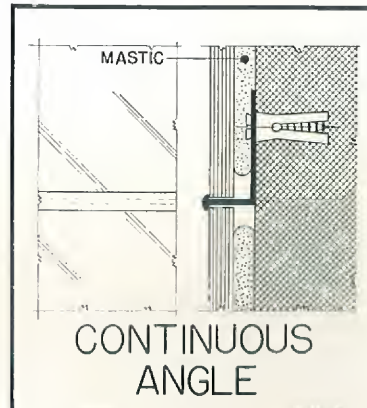
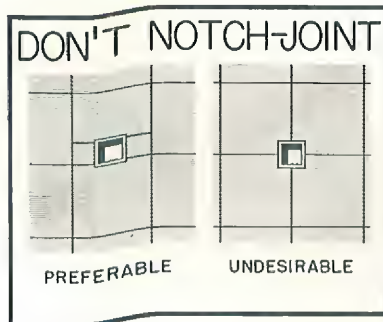
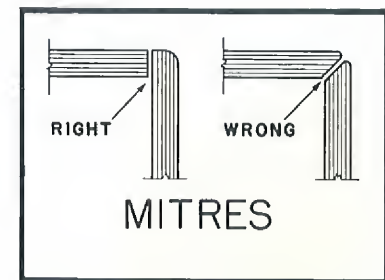
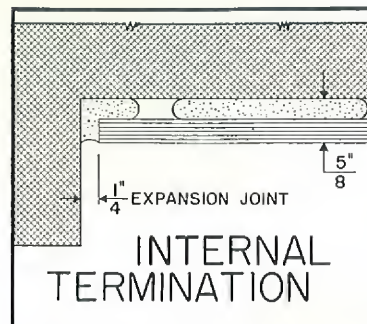
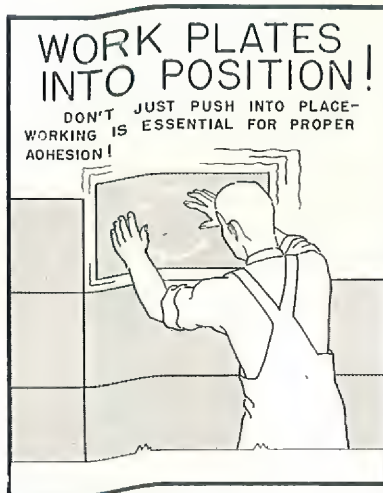
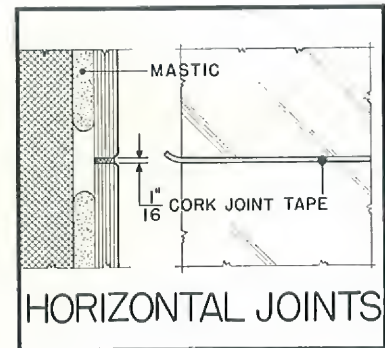
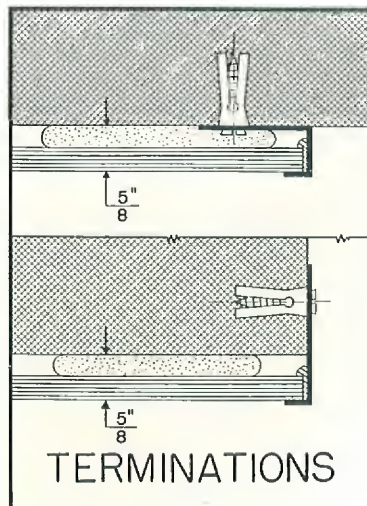
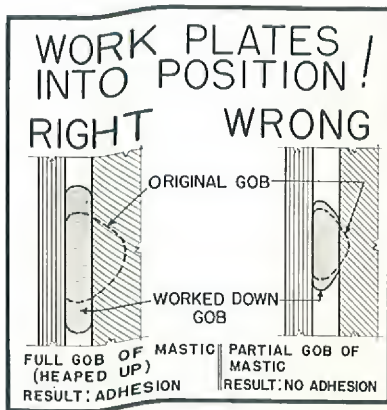
Place the stiles in position and block them up at the bottom with wood, or plaster of Paris, to the correct height. Until the plaster on both partition and stile has had a chance to set, it would be well to brace the glass with wood members, so that they will remain plumb and true. Upon completion of setting the stiles, one may proceed with the setting of the wainscot and cap in the toilet compartments proper. Having finished the compartments, the wainscot and cap in the balance of the room may be set.

HARDWARE

The manner in which the hardware is applied will effect the durability of the job. All hardware, whether that used in erection or accessories, such as hinges, strikes, paper holders, etc., should be buttered with pointing compound before application, and the fastenings should not be pulled down hard, but just firmly enough to keep them in place and prevent loosening. When the pointing compound hardens, this leaves a uniform bed under the metal, so that it will not move and spall the glass.

Before leaving the job, install any hardware of other contractors, since it is almost certain that if left to themselves, they will do it incorrectly.

Check the swing of all doors, such as medicine cabinets.



SOME HINTS AND
CLOSE-UP DETAILS

entrance, and toilet compartments, and see that they do not come in contact with the glass, and that proper bumpers have been supplied.

If any conditions are such that damage might result, notify the contractor in writing.

CLEANING

When making the installation, it is well to have on hand several containers in which to throw debris, broken glass, etc. If the general contractor obligingly takes away the refuse and the old crates, do not assume that he is being a good fellow, because there will probably be a substantial charge for this at the end of the contract. Ascertain whether or not it is his intention to charge for this service. If so, it may be possible to arrange to have the material removed cheaper.

INSPECTIONS AND COMPLETION

Upon completion of the setting of the glass, do not do the final cleaning, but ask the contractor's inspector to examine the room and secure his release, so that you may have the general contractor call in other trades to finish the balance of the room, such as plasterers, plumbers, etc. If release is given by the contractor's inspector, any damage resulting from the work of these trades must be made good by them, and will not be charged to the glass contractor.

Upon making sure of the completion of the work of other trades in the room, the final cleaning and pointing of the joints can be done. After final pointing and cleaning, one should again call the contractor's inspector, and secure his final written approval and acceptance of the room, which completes the glass contractor's work.

ORDERING

Attention to the following will help the factory or shop to fill an order promptly and efficiently.

Terms such as bullnose, halfround, etc., through usage may have a specific meaning in your office, and yet mean nothing to the factory. A small cross-section of the edge wanted is always understandable.

Put all the information on either the drawing or the order. There is always more chance for error when part of the information must be sorted out of one or several letters.

Make certain that individual dimensions of plates check with over-all dimensions.

Indicate clearly whether dimensions are to face of Carrara or not.

If mitered edges are specified, indicate if they are on the face or back of glass.

If a list of sizes is furnished in connection with a drawing, check it to see that the list is correct. When it is not correct, it is worse than useless and confuses the shop. It is surprising how often an error occurs.

Furnish a sketch if possible; even a rough one, if properly dimensioned, is valuable.

When dealing with structural glass, which is opaque and not reversible, it is not sufficient to specify edgework such as one long and one short polished. It is necessary to know which long or short is required to be finished.

Do not specify heavy glass with clean-cut edges. It cannot be furnished. Due to flare, the underside is apt to be considerably longer or shorter than the top. If accuracy is required, ground edges should be specified.

On sketches use the following standard symbols for edge finishes.

Polished Edge.....	✂	Cut Edge.....	/
Ground Edge.....	X	Pol. Miter.....	✂M
Ground Miter.....		XM	

Structural Mirror Installation



The handsome furnishings of this dining room are doubly attractive through the reflections of the structural mirror wall.

MIRROR INSTALLATIONS

MIRRORS are used for many different purposes where special installation is not a requisite. It is, however, frequently desired to make permanent installations of mirrors on many different

types of surface. Indirect vision mirrors are frequently installed at road intersections, on elevators, streetcars and for other similar safety uses. These installations require careful study of location and background to determine the final method of application.

Mirrors may be installed with rosettes, beads, molding and mastic settings. If mastic is used, it is good practice to use a molding rail or metal clips to carry the weight—the mastic merely holding the mirror against the wall.

Where structural mirrors are to be installed in existing buildings, the measurements for the mirror must be carefully determined and the mirror cut to correct size. In many instances, it is necessary to prepare patterns. The mirror glass is cut at the mirror shop, all necessary edgework done and the finished mirror delivered to the job site ready for installation.

Mirror installations may be made in several different ways:

a. Holes may be drilled through the mirror glass and the mirror supported by screws securely anchored into lead wool plugs rammed into corresponding holes provided in the wall. Rosettes are used to conceal the screw holes and to provide some decoration. These mirrors are usually of the unframed Venetian type with finished edges.

b. Venetian-type mirrors, backed with plywood or fiberboard, may also be supported by relatively small, almost invisible metal clips attached to the back, and anchored to the wall by screws.

c. Wood molding or beads may be affixed to the wall so as to provide a frame for the mirror and to support the mirror securely in place.

d. Structural mirrors may be adhered to vertical surfaces by the use of an approved mirror mastic which provides an effective bond between the glass and the wall surface. The mastic, properly distributed, is a very satisfactory adhesive. Where it is planned to install a number of mirrors on the same plane, thoroughly seasoned wood grounds should be provided in the wall and the exposed wooden surfaces brought into one true plane. The wood grounds should extend only far enough from the wall so that the mirrors may be set evenly against the grounds. The mirrors are held in place against the wall by means of properly distributed gobs of mirror mastic and pressed into a uniform plane by squeezing the mastic between the glass and the wall surface. Where needed, metal clips are provided at the horizontal joints of the mirrors to assist in supporting the weight of the mirrors.

Mirrors should always be set so that repeated

long cycles of condensation and evaporation may not occur upon the mirror backing. Condensation of moisture upon the back of a mirror is always dangerous, especially when the water remains long in contact. Where it is anticipated that these conditions may be encountered, copper backed structural mirrors should always be used, or occasionally the mirror may be set solidly in a complete bed of mirror mastic. Copper backed mirrors are much less susceptible to deterioration from this cause than are ordinary mirrors. The plain structural mirrors have been designed to meet most usual requirements of this sort, but copper backed structural mirrors are especially designed for use where provision must be made for unusually severe exposures.

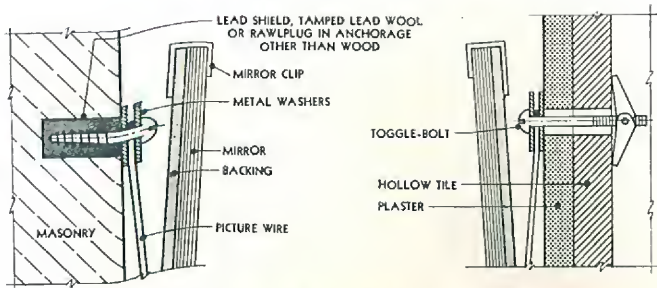
If by any means possible, ventilation should be provided, so that any condensation which may occur shall again evaporate as rapidly and promptly as possible.

Occasionally, provision must be made for actual immersion of the mirrors in water, involving either partial or complete immersion, and in any cases of this kind, the question should be referred to the mirror department. Varying conditions call for varying solutions of the problem, and often for very special fabrication.

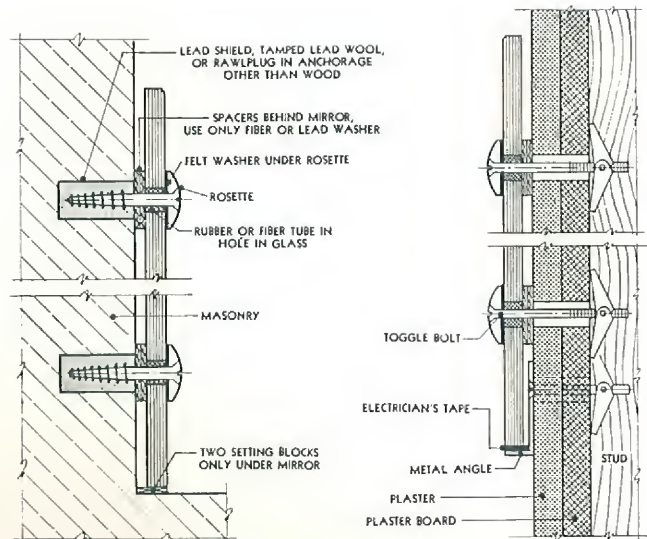
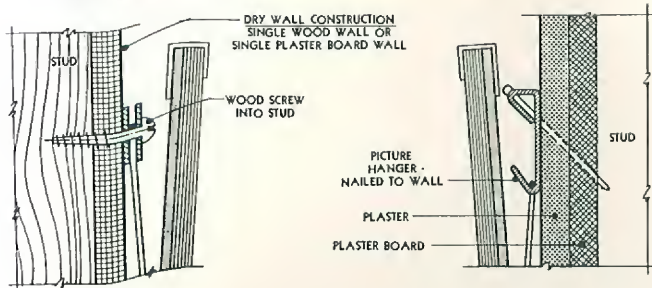
In all cases mirrors must be protected against sulphur. Continued exposure to sulphur vapor in the air, even in very small amounts, will eventually and surely cause deterioration of the mirror. Ordinary rubber articles, such as rubber bands, rubber gloves, and so on, contain sufficient free sulphur to cause serious spoilage of the mirror, if left long in contact with the backing of the silver—the glass face of the mirror affords complete protection. Rubber should never be used in the setting of mirrors of any type.

Certain types of leather seem to be very deleterious to mirrors and it is therefore an excellent precaution to avoid the use of any type of leather in mirror installations.

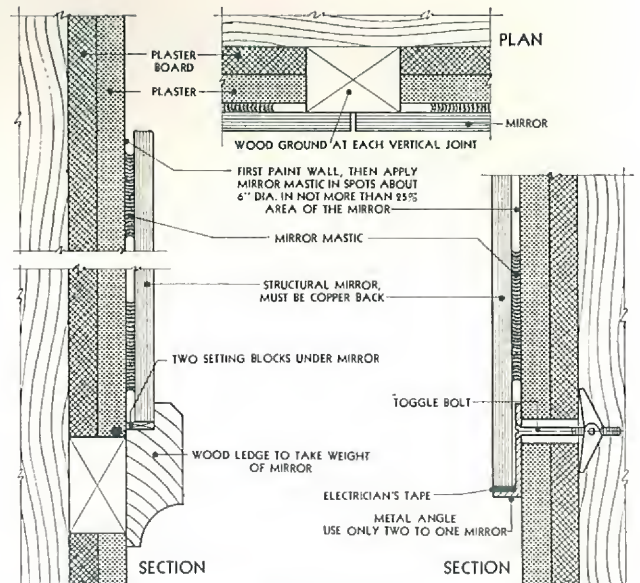
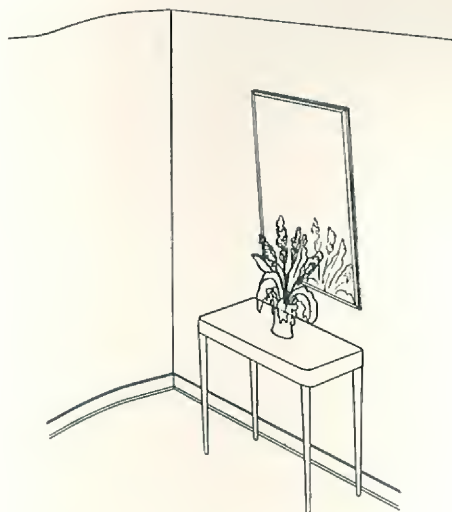
Part of the difficulty with leather results from its capacity to absorb and hold large amounts of moisture. This is also true of felt and some porous unglazed fiberboards. It is therefore good practice to avoid the permanent installation of mirrors with any type of backing which is absorbent or contains free sulphur or other injurious chemical.



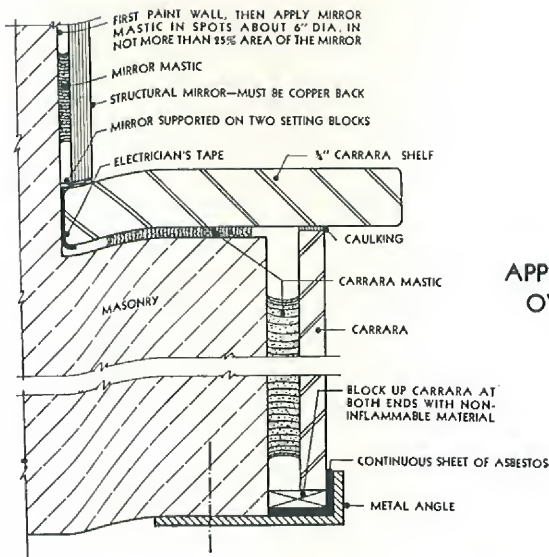
METHOD OF HANGING MIRRORS ON WALL



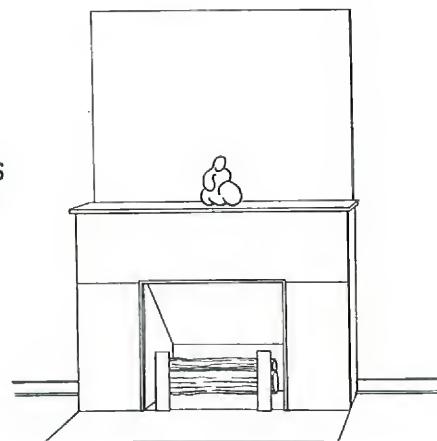
METHOD OF FASTENING MIRROR WITH ROSETTES
OVER LEDGE NO LEDGE

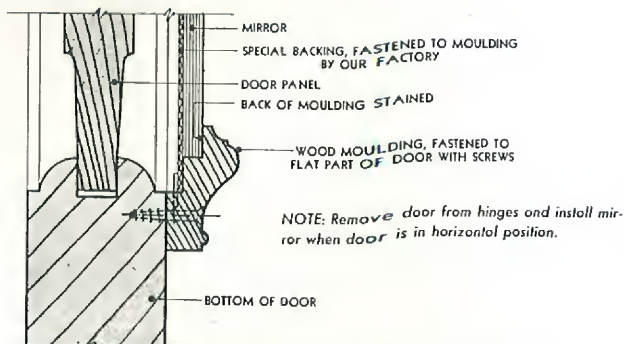


METHOD OF MIRROR APPLICATION TO PLASTER WALL
WITHOUT ROSETTES

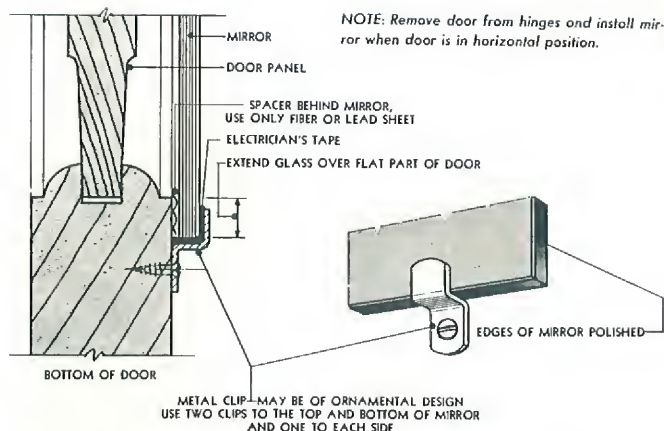


APPLICATION OF GLASS
OVER AND AROUND
FIREPLACE

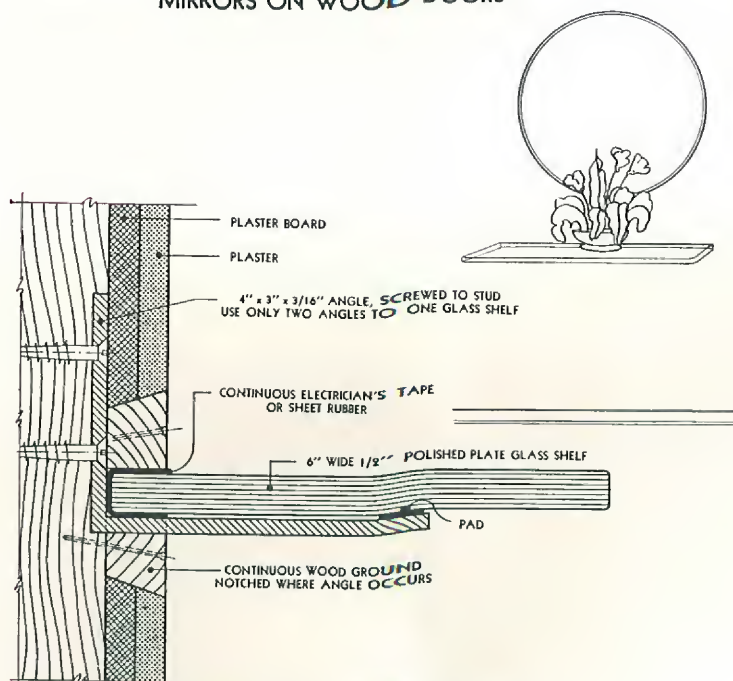




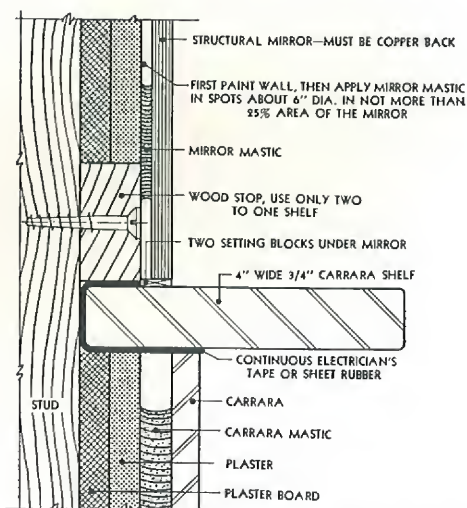
INSTALLATION OF FACTORY FRAMED MIRRORS ON WOOD DOORS



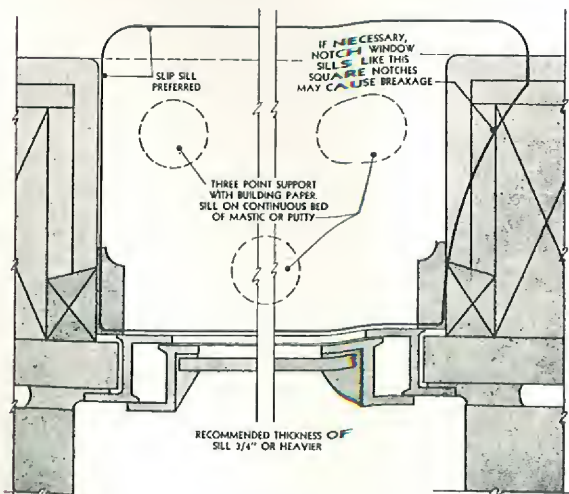
INSTALLATION OF VENETIAN MIRRORS ON WOOD DOOR



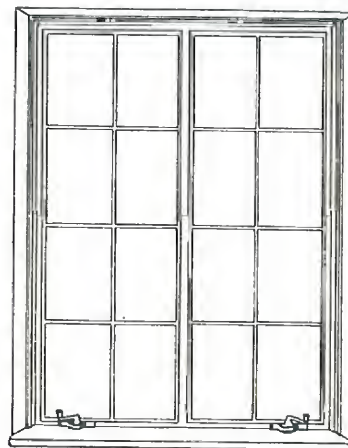
METHOD OF GLASS SHELF INSTALLATION IN CASE OF PLASTER WALL USING METAL BRACKET



METHOD OF GLASS SHELF INSTALLATION IN CASE OF PLASTER WALL WITHOUT METAL BRACKET



PLAN OF CARRARA GLASS INTERIOR WINDOW SILL





A cordial reception is offered by a free hanging period wall mirror in an attractive entranceway.

Auto Glass Parts



Speed is essential in the replacement of Auto glass. The motorcycle does the job.

IN 1937 the Company organized the Auto Glass Installation Service which has come to be a well-established branch of the warehouse business. The service offered includes the replacement of automobile glass both in warehouse shops and in the field by trained and skilled servicemen. Sidecar motorcycles equipped with compartments for carrying glass, provide excellent and rapid service to garages, automobile fleet owners, service stations or the individual automobile owner.

This auto glass replacement service is of especial interest to insurance companies whose comprehensive automobile liability coverage includes the replacement of glass. The requirements of the insurance companies have produced a considerable volume of auto glass replacement business.

Company figures indicate that the replacement business will continue to be of very great volume and the Pittsburgh Plate Glass Company auto glass replacement service should be of great value to the auto glass replacement shops and automobile dealer repair shops.

The Automobile Glass Catalog provides all pertinent information on the size of glass used in every model of automobile since 1936—and is divided into 3 sections.

An alphabetical listing makes up the first section, showing all makes and models of passenger cars and trucks with the part numbers and corresponding glass parts to fit every opening. Here also are shown the list prices for each part in laminated safety plate glass, laminated safety sheet glass, polished plate glass and heavy sheet glass. Also where needed, the list prices for bent tempered plate glass backlights are shown. This section contains all necessary information for the correct ordering of replacement glass parts, such as model numbers, job numbers, serial numbers, and type of car.

The name of the car is placed on the upper outside corner of each page to enable quick reference.

Interchangeable parts are shown in the second section and the tabulation covers every part number and corresponding glass part contained in the

CHRYSLER

1942-1941

The Model in Letters and Serial Number will be found on the dash under the hood or stamped on left side of Motor Block.

Models—C28S, 34S Royal C28W, 34W Windsor.
Models—C30K, 36K Saratoga, C30N, 36N New Yorker.
Models—C33, C37, Custom and Crown Imperial.

COUPE—Club 3-6 Pass. Models C28S, 34S, Royal.
C28W, 34W Windsor. C30K, 36K Saratoga.
C30N, 36N New Yorker.

Part Number	Safety Glass	Safety Glass	Polished Glass	Heavy Sheet Glass
6552 Windshield (2), each	8.94	5.69	3.25	1.56
6559 Door Vent	2.75	1.75	.80	.39
6558 Quarter (Club Cpe)	7.49	4.76	2.72	1.31
6562 Quarter (Bent Tempered) (Club)	6.95	4.42	2.28	1.14
6571 Back (Bent Tempered) (4Pass)	12.68			
6572 Back (Bent Tempered) (4Pass)	14.71			

COUPE—Club Convertible. Models C28W, 34W.
C30N, 36N Windsor and New Yorker.

Part Number	Safety Glass	Safety Glass	Polished Glass	Heavy Sheet Glass
6553 Windshield (2), each	7.94	5.06	2.29	1.39
6564 Door Vent	2.75	1.75	.80	.39
6567 Door	6.95	4.42	2.28	1.14
6573 Quarter	4.81	3.06	1.40	.79
6446 Back	2.75	1.75	.80	.39

BROUGHAM—Victoria Sedan. 2Dr. 5P.
Models C28S, 34S Royal; C28W, 34W Windsor.
C30K, 36K Saratoga; C30N, 36N New Yorker.

Part Number	Safety Glass	Safety Glass	Polished Glass	Heavy Sheet Glass
6552 Windshield (2), each	8.94	5.69	3.25	1.56
6559 Door Vent	2.75	1.75	.80	.39
6558 Quarter	6.95	4.42	2.28	1.14
6566 Quarter Vent	2.50			
6563 Quarter Vent	15.27			
6570 Back (Bent Tempered)				

SEDAN—Town. 4D-6P. Models C28W, 34W Windsor; C30K, 36K Saratoga; C30N, 36N New Yorker.

Part Number	Safety Glass	Safety Glass	Polished Glass	Heavy Sheet Glass
6552 Windshield (2), each	8.94	5.69	3.25	1.56
6559 Front Door Vent	2.75	1.75	.80	.39
6557 Front Door	6.95	4.42	2.28	1.14
6554 Rear Door Vent	2.50			
6565 Partition (C30N)	15.27			
6465 Back (Bent Tempered)				
6570 Back (Bent Tempered)				

SEDAN—4D-6P. Models C28W, 34W Windsor; C30N, 36N New Yorker.

Part Number	Safety Glass	Safety Glass	Polished Glass	Heavy Sheet Glass
6552 Windshield (2), each	8.94	5.69	3.25	1.56
6559 Front Door Vent	2.75	1.75	.80	.39
6557 Front Door	6.95	4.42	2.28	1.14
6554 Rear Door Vent	2.50			
6565 Partition (C30N)	15.27			
6465 Back (Bent Tempered)				
6570 Back (Bent Tempered)				

SEDAN—4D, 6 and 34W. C33, C Imperial.

Part Number	Safety Glass	Safety Glass	Polished Glass	Heavy Sheet Glass
6552 Wind. (2)	8.94	5.69	3.25	1.56
6559 Wind. (Be)	2.75	1.75	.80	.39
6557 Front Do	6.95	4.42	2.28	1.14
6554 Rear Do	2.50			
6561 Quarter (Vent'g)	15.27			
6465 Part.				
6568 Part.				
6570 Back				

1942-1941

STATION WAGON—Models C28, C34W, Chrysler Windsor. 6 and 9 Pass.

Note: 6 Pass. No. Quarter Front or Vent.
9 Pass. With Quarter Front and Vent.

Part Number	Safety Glass	Safety Glass	Polished Glass	Heavy Sheet Glass
6552 Windshield (2), each	8.94	5.69	3.25	1.56
6559 Front Door Vent	2.75	1.75	.80	.39
6558 Front Door (Side) (2), each	6.11	3.89	2.00	1.09
6575 Rear Door (Side) (2), each	3.74	2.38	1.09	.61
6574 Quarter Front (1st Srs. 1941)	3.74	2.38	1.09	.61
6576 Quarter Front (1st Srs. 1941 & 1942)	3.09	1.94	.89	.50
6579 Quarter Vent	15.26			
6577 Back (Bent Tempered)				
6570 Back (Bent Tempered)				

1940

The model in letters and serial number will be found on the dash under the hood or stamped in left side of motor block.

Model C25S—Royal, 6-cyl., 122" and 139" W.B.
Model C25W—Windsor, 6-cyl., 122" and 139" W.B.
Model C26K—Traveler, 8-cyl., 128" W.B.
Model C26N—New Yorker, 8-cyl., 128" W.B.
Model C26S—Saratoga, 8-cyl., 145" W.B.
Model C27—Custom Crown Imperial 8-cyl.

COUPE, 3-6-P. Models C25S-Royal, C25W-Windsor, C26N-New Yorker, C26K-Traveler.

Part Number	Safety Glass	Safety Glass	Polished Glass	Heavy Sheet Glass
6552 Windshield (2 req.), each	7.33	4.57	2.40	1.20
6559 Front Door Vent	2.50	1.67	.87	.32
6558 Front Door (with Vent)	4.42	2.28	1.14	.56
6554 Rear Door (no Vent)	4.13	2.63	1.20	.68
6557 Rear Door (1st Series)	8.25	5.25	3.00	1.44

Windsor, C26N.

CHRYSLER

1935

SEDAN, 4D-7P. Model C-Z, De Luxe, Airstream, Traveler, 7-P. De Luxe Model C-Z, Airstream, With Trunk

Part Number	Safety Glass	Safety Glass	Polished Glass	Heavy Sheet Glass
6364 Windshield	11.23	7.15	4.08	1.96
6367 Front Door	9.09	5.78	3.11	1.59
6363 Rear Door	8.56	5.44	3.11	1.59
6366 Quarter (Traveler)	3.21	2.04	1.11	.59
6377 Quarter (Sedan 7-P.)	1.81	1.46	.79	.34
6375 Back	5.73	3.65	1.87	.94

CHRYSLER AIRFLOW

The model in letters will be found stamped in front of motor block. The serial number will be found on metal plate on door post.

1935 Model C-1, Chrysler Airflow, 8-Cyl., Serial 6601201 and up.
1935 Model C-2, Chrysler Airflow, 8-Cyl., Serial 7012201 and up.
1935 Model C-3, Custom Imperial Airflow, Imperial 8, Serial 7012201 and up.
1935 Model CW, Custom Imperial Airflow, Serial 7528551 and up.
Note: Model C-1, "First Series," without ventilation.
Model C-1, "Second Series," with ventilation.

COUPE—5-Pass., Model C-1, Airflow 8, First and Second Series

Part Number	Safety Glass	Safety Glass	Polished Glass	Heavy Sheet Glass
6363 Windshield (2 req.), each	6.95	4.42	2.28	1.14
6364 Door Vent (2nd Series)	2.50	1.67	.87	.32
6367 Front Door (2nd Series)	5.88	3.74	1.93	.96
6368 Quarter Front (1st Ser.) (no Vent)	5.88	3.74	1.93	.96
6374 Quarter Front	2.75	1.75	1.00	.50
6379 Quarter Rear	2.92	1.94	.80	.39
6379 Back (2 req.), each	4.89	3.11	1.42	.80

COUPE, 5-Pass., Model C-2, Imperial Airflow (With Ventilation)

Part Number	Safety Glass	Safety Glass	Polished Glass	Heavy Sheet Glass
6363 Windshield (2 req.), each	6.95	4.42	2.28	1.14
6364 Door Vent	2.50	1.67	.87	.32
6367 Front Door	5.88	3.74	1.93	.96
6368 Quarter Front	4.81	3.06	1.40	.79
6379 Quarter Rear	2.92	1.94	.80	.39
6379 Back	4.89	3.11	1.42	.80

SEDAN—4D-6P. Model C-1, Airflow 8 (1st Series)

5-Pass. (Second Series)
TOWN—4D-6P. Model C-1, Airflow 8 (1st Series)

5-Pass. (Second Series)

Part Number	Safety Glass	Safety Glass	Polished Glass	Heavy Sheet Glass
6363 Windshield (2 req.), each	6.95	4.42	2.28	1.14
6364 Frt. Door Vent (2nd Ser.)	2.50	1.67	.87	.32
6367 Frt. Door (with Vent)	5.88	3.74	1.93	.96
6368 Frt. Door (no Vent)	3.21	2.04	1.11	.59
6366 Rear Door (1st Series)	6.95	4.42	2.28	1.14
6365 Quarter (Reg. Sedan)	6.95	4.42	2.28	1.14
6390 Quarter (Reg. Sedan)	3.82	2.43	1.11	.56
6367 Back (2 req., each)	3.44	2.19	1.00	.56
	4.81	3.06	1.40	.79

SEDAN, 4D-6P. Model C-2, Imperial Airflow (With Ventilation)

Part Number	Safety Glass	Safety Glass	Polished Glass	Heavy Sheet Glass
6363 Windshield (2 req.), each	6.95	4.42	2.28	1.14
6364 Front Door Vent	2.50	1.67	.87	.32
6367 Front Door	5.88	3.74	1.93	.96
6368 Quarter Front	3.21	2.04	1.11	.59
6372 Quarter Rear	6.95	4.42	2.28	1.14
6367 Back (2 req.), each	2.50	1.67	.87	.32
	3.06	1.94	.89	.50
	4.81	3.06	1.40	.79

SEDAN, 4D-8-Pass., Models C-3, CW, Imperial Airflow 8, Imperial Sedan, C3, CW, Town-Sedan, C-3, CW, Town-Limousine, C-3, CW, Sedan-Limousine, C-3, CW

Part Number	Safety Glass	Safety Glass	Polished Glass	Heavy Sheet Glass
6363 Windshield (2 req.), each	6.95	4.42	2.28	1.14
6364 Front Door Vent	2.50	1.67	.87	.32
6367 Front Door	5.88	3.74	1.93	.96
6368 Quarter Front	3.21	2.04	1.11	.59
6372 Quarter Rear	6.95	4.42	2.28	1.14
6367 Back (Mod. C-3)	2.50	1.67	.87	.32
6373 Quarter Front	3.06	1.94	.89	.50
6367 Back	4.81	3.06	1.40	.79

From 1926 to the present, a comprehensive and effective catalog of sizes, shapes and prices is maintained for the auto trade.

catalogs. It shows all makes and models which each part will fit. Reference to this section should enable maintenance of a complete stock of auto glass parts without duplication of inventory or excessive investment.

The third section gives a consecutive listing of all part numbers, corresponding glass parts, sizes of parts, and list prices for the various types of glass which may be required.

In some instances, the desired part may not be



Removing door-light frame.



Cutting first side of glass to contour.



Both sides cut ready for removal of waste.



Waste edges have been cut free.



Smoothing the edges of finished glass.



Setting glass securely in channel.

listed, so there is also included a complete tabulation of glass sizes with the corresponding list prices from 4 inches by 18 inches up to 24 inches by 56 inches, and 26 inches by 28 inches. The glass opening is measured, and the price shown for the next higher even inch dimension should apply.

Pittsburgh Plate Glass Company auto glass replacement shops are strategically located to offer prompt and efficient service to automobile dealers, garages, automobile fleet owners, service stations, insurance companies, and in emergencies, to the individual automobile owner.

Automobile glass replacement involves removing the frames of windshields, body lights or door lights and installation of the glass in the channel frames of the car windows. Skilled installation men provided with glass cut to size, the necessary setting materials such as channel shapes, felt strips, everseal tape, and hammer, screw driver, pliers, etc., can install automobile glass with a minimum of difficulty and little loss of time.

Many of the requirements of window glazing apply to the setting of auto glass parts, but the observance of some special precautions will help to insure satisfaction to customers and to avoid

recurrence of breakage and additional expense.

Frames or channels must be straight. A slight bend is often sufficient to crack the glass.

A rubber mallet should be used for forcing the glass safely and easily into the channel. Sharp or hard tools are dangerous and their use for installing glass should always be avoided.

Glass parts should be set firmly in the frame or channel, with a good grade of cork and rubber fabric or other approved packing material.

If the side run of channel on body lights is worn out, new channels should be installed.

All broken glass and fabric must be removed from the frame or channel before starting to make the replacement.

When car has been in a wreck, or the door frame has been sprung, the opening should be checked. A paper pattern of the glass part desired should be made, since the original factory part may not fit the opening. Ascertain that the channel will receive the glass without strain.

After installation, raise and lower the glass part in channel to determine that the glass moves freely and does not rattle.

Replacements



The blurry figures illustrate the nicely timed co-ordination of the workmen in handling large lights, from the man at the top whose right hand only is blurred to the entirely moving man at the right.

AN IMPORTANT part of Company business results from the breakage of windows and other glass which may become broken from different causes, and under many different circumstances.

In many instances, glass is insured against breakage and contracts are entered into between the warehouse and the various insurance companies covering the prompt replacement of any glass covered by their policies. This insurance coverage applies generally to store fronts, display windows, industrial buildings and may frequently include residences, apartment houses, and other similar structures.

Many industries use considerable volumes of glass in their operations and breakage of these plates, as well as other uninsured glass, must be promptly handled.

When a glass breaks, it frequently happens that the owner will call the warehouse direct to report the breakage or, if insured, the insurance carrier will call giving the name of the owner, the address and other pertinent information. A man from the warehouse will measure the size of the glass to be replaced and if necessary, quote the insurance carrier or the owner on the cost of replacement and await their decision.



The strap, seen in the lower middle is a standard tool in the kit of the large light glazier. Its use is plainly seen here.



The glass rests on felt-covered blocks while being aligned with the ends of the frame.

REPLACEMENTS

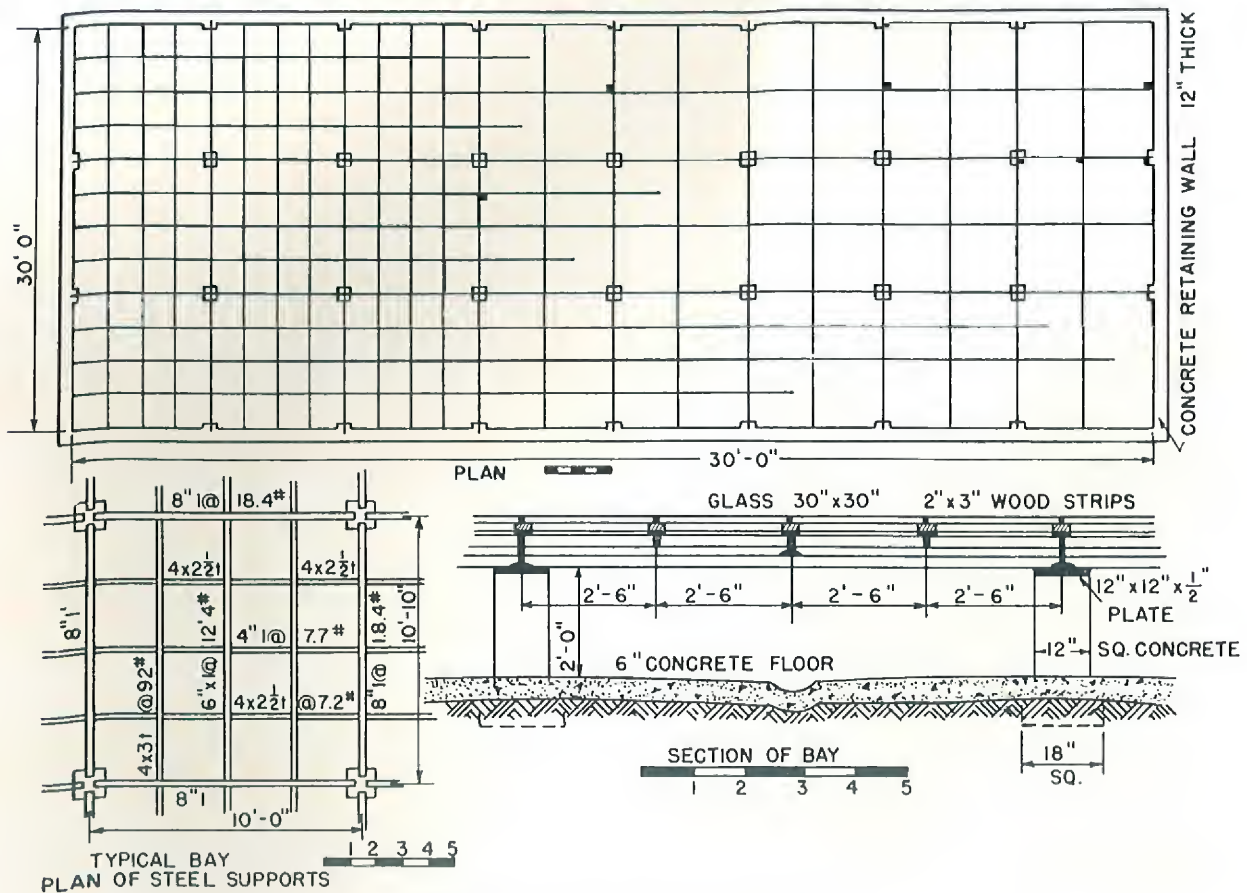
The setting of replacement glass is quite as involved and difficult as the initial setting of the original glass—or it may be exactly as simple.

The sash or rabbet into which the glass is to go, must be thoroughly freed of any old, dry, hard putty, old setting clips or glaziers' points, and the sash primed, if wood, or repainted if of steel. It is particularly important that steel sash shall be scraped clean and the rabbet repainted before new glass is set, to ensure that the sash members shall not rust and thereby cause renewed breakage of the glass. Where rust is allowed to build up against the edges of a light of glass it will sooner

or later develop sufficient pressure to break even the heaviest glass. This pressure will be transmitted through the hardened putty—and rusting, once started, will continue and spread, until scraped clean and repainted. Wood sash, old or new, should be primed so that the oil from the putty may not be absorbed by the wood and the putty rendered chalky or spongy.

When instructions have been received from the owner or insurance carrier that the glass is to be set, the required replacement lights are cut to size at the warehouse, and delivered to the job, along with the glazier or glazing crew if needed. All the necessary precautions outlined are carried out, and the broken lights replaced.

Glass Floors



Suggested Details for outdoor floor construction.

ALTHOUGH there are several types of flooring which include the use of glass in one way or another, there is only one which will be considered in this section in detail. Solid floors in which the opaque structural glasses may be laid in plain or mosaic patterns against a suitable base are used in a number of installations. However, of greater interest and importance are the solid glass floors built of translucent glass and frequently used as dance floors with decorative and ornamental purposes.

The Pittsburgh Plate Glass Company cannot accept any responsibility for any injuries resulting from the breakage of glass in dance floors and other similar applications, and the data included herewith are offered with that definite understanding.

Glass floors should always be laid against wood supports. The wood members should be fastened to steel supporting members, unless they are sufficiently strong to bear the expected loads and vibrations. After being set in place, the wood

understructure should be planed level and smooth, and faced with felt, or waterproof mastic cement, to carry the glass and assure uniformity of bearing.

Where illumination is provided under the glass, care must be exercised to see that ample air circulation is provided, and that the heating of the glass by the lamps is not excessive. In many instances it may be desirable, even imperative, to interpose heat-absorbing glasses between the light source and the floor. This will be particularly true where high-powered lamps are used. The temperature against regular glass should never exceed 100°F., though the temperature on Herculite may run materially higher, without danger.

For floors, Herculite in the form of either heavy rough plate glass or heavy plate glass, sandblasted on one side, should be used although, in some cases, regular glass may be satisfactory. Heavy rough plate glass has an advantage over polished plate glass in that it is not transparent. The face of heavy rough plate glass is sufficiently smooth to present a satisfactory floor surface, although it is not as smooth as the polished product.

It is particularly urged that care be exercised in using the proper glass thickness for varying areas of individual glass plates used to make up a floor, as shown in chart, Section J-1 • 17. One inch bearing must be provided on all edges.

The edge of the glass plates should be ground to insure proper fitting.

Where unroofed areas are to be floored with glass, the plates should be spaced at least $\frac{1}{8}$ inch apart, and the spaces nearly filled with a waterproof mastic cement. It is essential that the cement used should remain pliable at all times.

The supporting structure must be amply strong to support the floor with minimum deflection, particularly in the case of dance floors, and there should be a minimum distance between the glass floor and an adequate subfloor to avoid injury to persons if the glass should break.

The design of the floor may be prepared by

anyone competent to do so and should be carefully checked by the proper persons in the warehouse organization. In most cases, a glass floor cannot be installed without considerable alteration to surrounding work and frequently the installation of additional structural supports. Therefore, the services of a competent architect or structural engineer, whose recommendations are acceptable to the local building authorities, should always be employed to engineer the installation.

In most instances, the owner will engage his own architect who will co-operate closely with the Company representatives until the work is successfully finished.

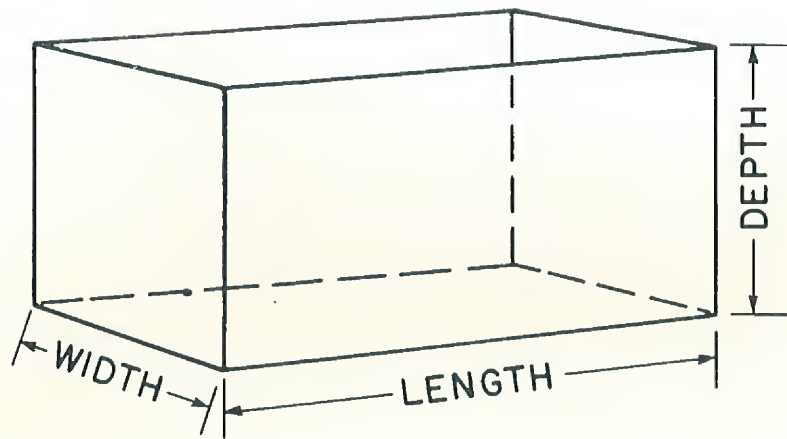
The entire responsibility for the installation must be centered on one individual or organization which may or may not necessitate a general contract. The Pittsburgh Plate Glass Company cannot assume the general contract responsibility and should assume only the responsibility for setting the glass as required.

The installation of illuminated floors, whether lighted from the edge of the glass or by flood-lighting beneath the glass, require the assistance of a qualified lighting engineer. In general, lighting may be introduced through the outer edges of the glass by separate light boxes or by providing a general illumination beneath the glass with occasional spotlights as desired. Colors may be provided either by the lighting means themselves or by a decorative design worked into the glass by sandblasting and coloring as in the Italian process.

Each installation of a glass floor is a distinct and separate operation. No two jobs are likely to be the same, and considerable study and experimentation may be necessary to secure the best results, unless very carefully engineered.

Negotiations for this type of work must be handled so that there shall be no possible implication that the Pittsburgh Plate Glass Company in any way guarantees the installation or any part of it, as a general construction contractor.

The Glazing of Aquariums



BASIC MEASUREMENTS

ONE of the many potential uses of glass which involve determination of adequate thickness and appropriate size is the glazing of aquariums. There are several different methods of installation which may be used with equal success and which depend primarily upon the preference of the owner of the aquarium.

The depth of the tank is the sole determining factor in establishing the pressure which will be applied to the glass. The width and length, whether in inches, feet or miles, have no effect upon the pressure exerted on the walls or floor of the tank. The pressures to which the walls of an aquarium are exposed may be calculated on the basis of the pressure exerted at the center of the area exposed to the water. Each foot of depth of fresh water produces a pressure of 0.433 pounds per square inch. If the aquarium has a glass bottom, the pressure exerted per square inch on the bottom will be 0.433 times the depth of the water in feet. On a glass panel in the side of an aquarium,

the pressure per square inch will be 0.433 times the depth of the water in feet above the center of the panel. When the pressure per square inch at the center of the glass panel and the total area of the glass are known, the thickness needed may be found by reference to the chart for safe loads for plate glass, Section J-1 • 16. (The pressure exerted by salt water will be 0.444 pounds per square inch per foot of depth.)

When the tank is entirely closed so that it may be subjected to additional air pressure, this additional pressure must also be taken into account in determining the thickness of glass to be used. It is sometimes necessary to subdivide the glass panel opening in order to provide glass of adequate strength for the installation.

The aquariums may be built entirely of glass with only small retaining angles to hold the glass in place, and the glass joints may be cemented with aquarium cement. In larger aquariums, the supporting framework may be steel channels into

which the glass is set with aquarium cement or they may be built up of cypress wood properly rabbeted to receive the glass. In large cement aquariums, either the steel channel setting method or the cypress sash method of setting the glass may be used.

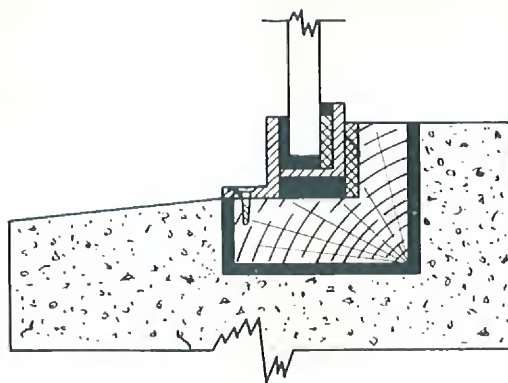
In a cement aquarium, the steel framework or the cypress framework may be set in place before the concrete is cast while, if the cypress framework is to be used, a recessed rabbet should be provided in the cement to subsequently receive the cypress setting.

The sash should be thoroughly bedded into the rabbet in a stiff mixture of putty, litharge and red lead in the proportion of 5-1-1, with the least possible amount of linseed oil to insure a tightly packed joint, and should be held securely by bolts or lag screws into the cement.

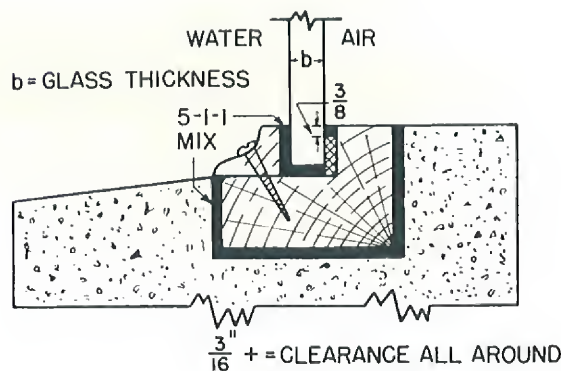
The frame against which the glass is to bear must be absolutely square and true so that there may be no uneven bearing of the glass from corner to corner or from edge to edge which would have a tendency to place the glass under strain. A substantial rubber gasket of the same general character as automobile inner-tube stock, at least $\frac{1}{4}$ inch thick, should be placed between the glass and the holding frame. This gasket should be solidly cemented against the retaining frame and also to the glass with a good grade of rubber cement. A recess at least $\frac{3}{8}$ inch deep should be left between the edge of the rubber and the edge of the frame and should be filled with the putty, litharge and red lead mixture after the glass is set.

The bearing of the glass against the rubber gasket should be at least equal to the thickness of the glass used.

The glass should be set in place by means of some supporting beams such as 2 x 4's or similar material. A gap of at least $\frac{3}{16}$ inch should be left between the edges of the glass and the frame at all points. The glass should be pressed securely into place and held by some supporting means until set. The gap left between the edges of the glass and the setting frame should be filled with the 5-1-1 mixture of putty, litharge and red lead of the consistency of a stiff paste. This mixture should be driven into place as tightly as may be possible and so that it shows a shiny surface of contact all about the glass. There should be no gaps where contact is not clearly evident. A small excess of this putty mixture should be left on the inside (water) face of the glass, to be further compressed by pulling down the setting bead or



Details of a setting employing wood (cypress), and steel angles and rubber gasket.

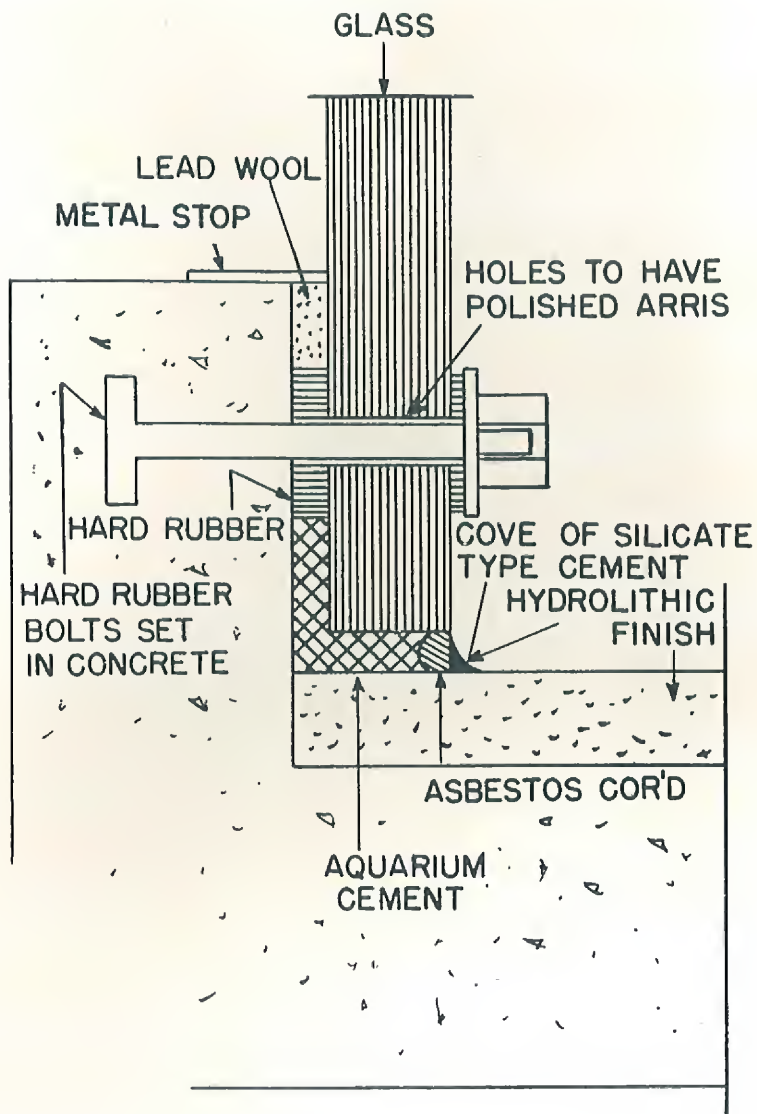


Details of an all wood setting. The dimensions here apply to the upper sketch also.

clamping means, securely against the glass and the putty compound.

Considerable time may elapse between the setting of the glass and filling the aquarium with water. During this time, if cypress wood is used for the sash, it may dry out sufficiently for leakage to develop. However, if the work has been properly done, the cypress should again swell and yield an entirely watertight installation.

The Pittsburgh Plate Glass Company cannot determine the materials to be used in building and equipping an aquarium and can undertake only to set the glass in place in a frame provided for the purpose by others. The suggestions made as to methods of setting have been found satisfactory in many instances and are offered as suggestions only.



DETAILS OF BOLTED SETTING

Skylights

Skylight glazing, because of the great number of patented construction types, should be described generally here. Detailed information is always available from the company and the skylight builder.

THE installation of skylights is a specialized field, covered by a number of firms whose principal business is the design and installation of skylights and ventilating equipment, in general. These skylights while similar in construction, vary considerably in the methods of glass installation.

Many skylights, known as dry skylights, are glazed without the use of putty or other glazing compounds. The glass is held in place by bars and screws. In some instances, the screws are used in conjunction with a spring that gives a uniform pressure, while in others the direct pressure of the screws is utilized. The direct pressure application is not so satisfactory as the spring pressure since the direct pressure tends to break the glass either during or shortly after installation.

Practically all patented skylights provide a condensation gutter on the inside to receive any leakage or condensation which may occur, and lead it to the outside through weep holes in the framing.

Where skylight glass is set in putty, the glass should be thoroughly bedded in putty and well faced. This gives the glass a good uniform bed upon which to rest, and helps to prevent any possible holes through which leakage may occur. In reglazing this type of skylight, the old putty should be entirely removed from the frame, and a new putty bed applied as on a new job.

Special care should be exercised to ascertain the proper dimensions for the skylight glass. The frames should be checked to insure that they are

in proper condition to receive the glass without strain along the edges, and any warped or bent portions of the frame should be aligned.

Many so-called skylights are of the monitor type, consisting of vertical sides equipped with steel sash to receive glass, and roofs of standard construction. These are glazed in the same manner as regular steel sash. The glass must be set without strains and the frame must be free from warp or projecting obstructions.

In general, the Pittsburgh Plate Glass Company cannot assume any responsibility for the weather-tightness of skylights beyond the exercise of due and proper care in the installation of the glass. Skylights should be and usually are glazed by the skylight installation contractor who necessarily assumes all responsibility for satisfactory results.

WINDOW VENTILATORS

In most instances, window ventilators are installed by building maintenance crews, or by the individual occupant or home owner himself. Light metal brackets or end pieces are usually furnished with the glass ventilator panel as a packaged item. The brackets are fastened to the jambs of the window with screws, usually at the bottom of the window and the glass slid into place. The glass panels are held loosely in the channels of the brackets and may be easily removed and replaced, as may be desired.

Windows

The glazing of windows, whether in metal sash or in wood is a general function of the warehouse crews. A large part is the glazing of new buildings which is covered by contract. A considerable volume of reglazing is done, usually on a more or less emergency basis.

THERE are several large producers of steel sash, bronze sash, aluminum sash and similar equipment, both for domestic and industrial application. These sash are installed by others under the general contract and Pittsburgh Plate Glass Company accepts responsibility only for the setting of the glass.

As a rule, the steel sash manufacturer paints the sash with a primer coat. In cases where this has not been done by the sash manufacturer, the sash must be painted with an adequate primer coat before any putty is applied, else the putty will not adhere properly to the sash. Bronze or aluminum sash need not be painted, but must be cleaned to remove any traces of protective coatings such as oil before putty is applied.

Glass set in metal sash should always be bedded in putty. That is, the rabbet of the sash should be filled with putty, and the glass forced home in the putty bed.

In steel sash, the muntins are provided with a number of small holes to receive glazing clips. The clips serve as glazing points and snap into place on the face or open side of the glass. They hold the glass in place by tight spring tension. Four to eight clips are used to a pane or light.

After the spring clips are in place, the open side of the glass is faced with putty, which should

extend over the face of the glass to the same depth as the metal on the opposite side. The surplus putty squeezed out of the bed between the glass and the sash member is now trimmed off flush with the metal, and the setting is complete.

In bronze and aluminum sash, the glass is usually held in place by setting beads or angles instead of clips. The glass is bedded in putty and faced as in steel sash glazing. The setting bead is then set against the facing putty and forced into place by screws threaded into the muntin bars and finally, the excess putty is trimmed flush with the metal of the frame.

Speed of setting is one of the prime prerequisites of a sash glazing job. Skilled glaziers acquire a knack or art of glazing which is difficult for the amateur to imitate.

Steel sash in which putty and glazing clips are used, is used principally in industrial or factory buildings. It is usually glazed from the exterior, except in some special types of structure. Metal sash in which setting beads are used is almost always glazed from the interior.

Wood sash is usually supplied glazed, but when necessary to reglaze wood sash, the methods used for steel sash are followed, substituting glaziers' points (small triangular pieces of zinc) for the glazing clips of the steel sash.

WINDOWS

The setting of small lights of glass up to approximately 48 inches square usually presents few problems in setting practice and seldom will involve the use of setting blocks. However, as the length of the glass increases, the use of setting blocks becomes more imperative if possible breakage of the glass is to be avoided.

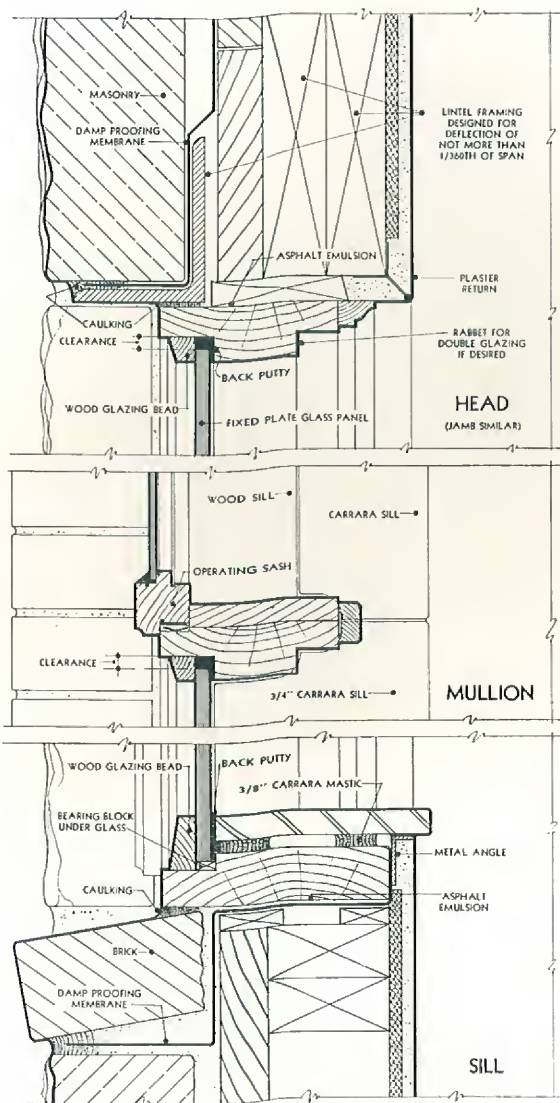
Large glass in windows, store fronts, and other framed panels, including large mirrored panels supported by framing, should always be set in what is called two-point suspension. That is to say, no attempt should be made to have a bearing against the glass the whole length of the supporting edge. Any such attempt is most likely to introduce or develop a localized center of support which will result in the breakage of the plate. The glass should rest definitely upon only two supports relatively close to the ends of the plate. These supports are called setting blocks and should not exceed four or five inches in length, by $\frac{1}{4}$ to $\frac{1}{2}$ inch in thickness. Preferably, they should be made of seasoned white pine wood although other materials such as rubber or even solid lead blocks may be used. The setting block should be so constructed that when the glass is set upon the lengthwise center line, the block shall extend at least $\frac{1}{8}$ inch beyond the glass on either side, if by any means practicable. This width is desirable in order to avoid having the glass slip off the block, as vibration of the glass may wear it away.

The setting blocks should be set so that the median line crosswise of the block shall be between 10 per cent and 15 per cent of the overall

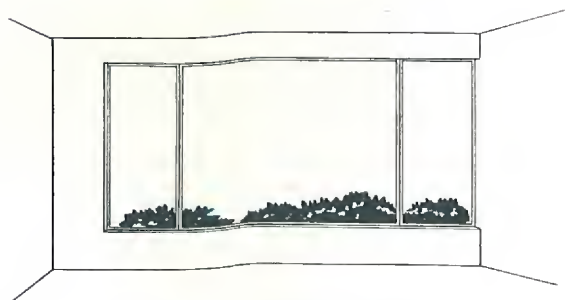
length of the glass from the end of the plate. Care should be exercised to insure that the edge of the glass where it bears upon the setting block is as nearly cleanly square as possible and that there are no flares at that point which might tend to chip and subsequently break the plate. Preferably, they should be rubbed off nearly smooth with an emery stone along this area of the edge.

When setting the glass into the frame, great care should be exercised to see that none of the setting screws or localized points of pressure come opposite the setting block. The retaining screws always produce an area of localized pressure immediately around them and when immediately adjacent to the setting block, this localized pressure may be dangerous, even though there is no possible contact between the bolt or screw and the glass.

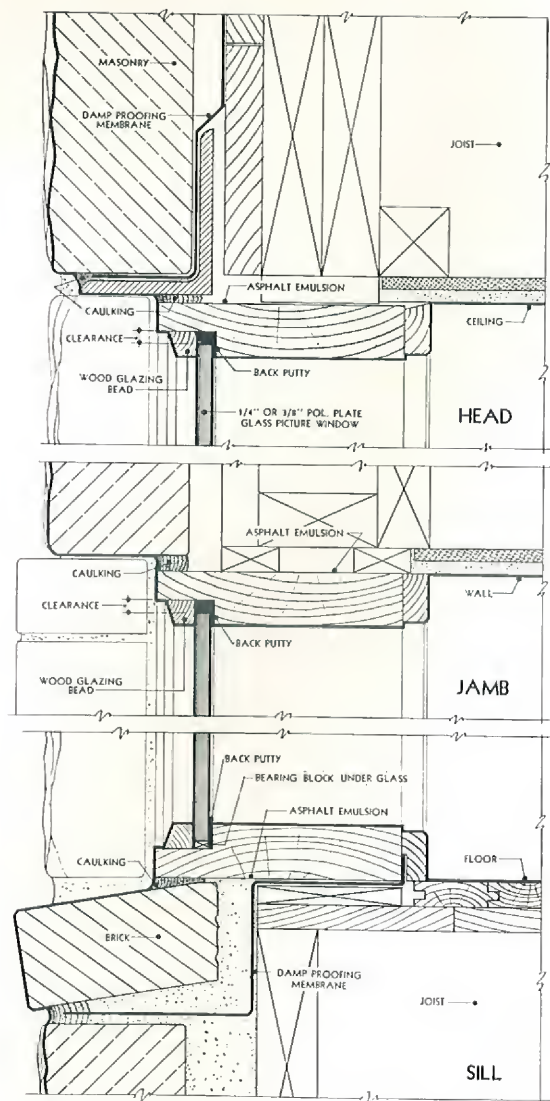
In general, glass should always be cut to allow from $\frac{1}{8}$ inch to $\frac{3}{16}$ inch clearance about the entire periphery of the glass, whether the sash be a metal sash or a wood sash. In usual household or domestic glazing, the glass will rest upon the bottom of the lower rabbet, without clearance, except that provided by the putty squeezed out beneath the glass from the back putty bed. Even here it would be good practice, though seldom followed, to provide small setting blocks under the glass. More usually, the glazier will depend upon his skill in setting the glass with ample bottom clearance. In the largest size glasses, the clearance allowed should be increased to $\frac{1}{4}$ inch to $\frac{3}{8}$ inch, depending upon the dimensions, with enough more to allow for the setting blocks used at the bottom.



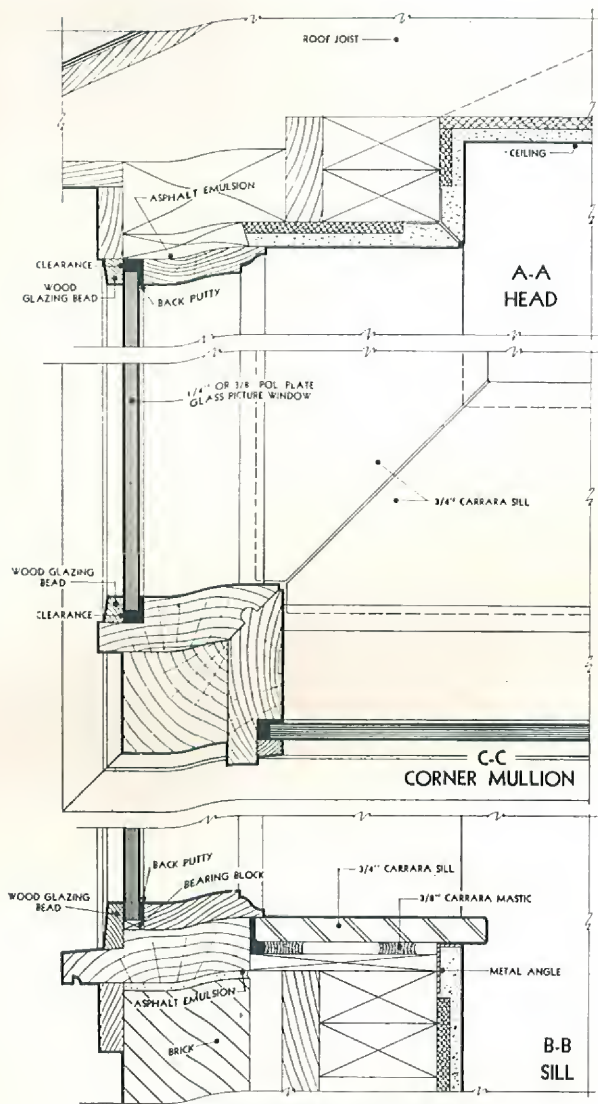
INSTALLATION DETAIL FOR A COMBINATION OF
PICTURE WINDOW AND OPERATING SASH



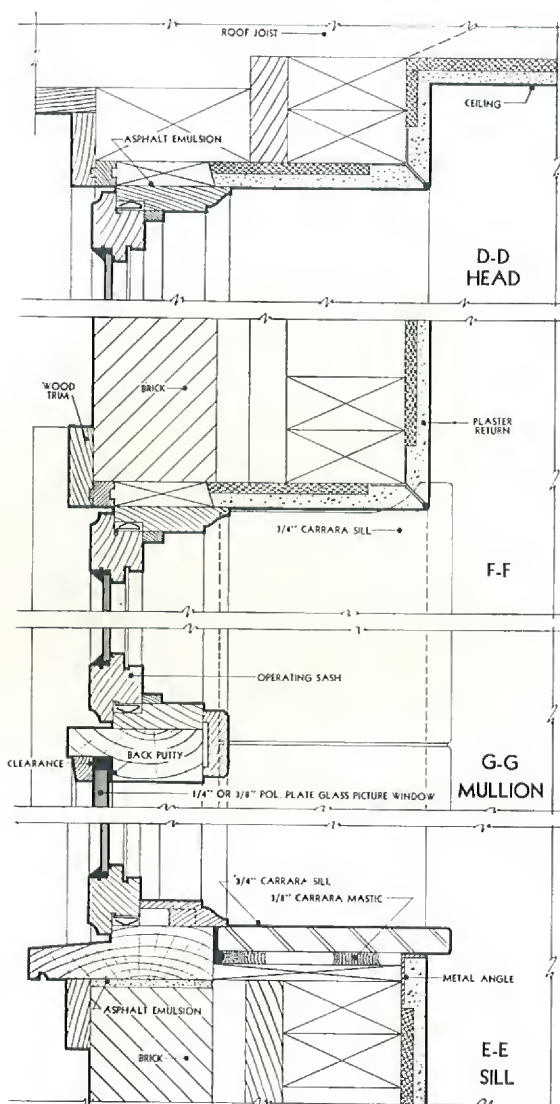
INSTALLATION DETAILS



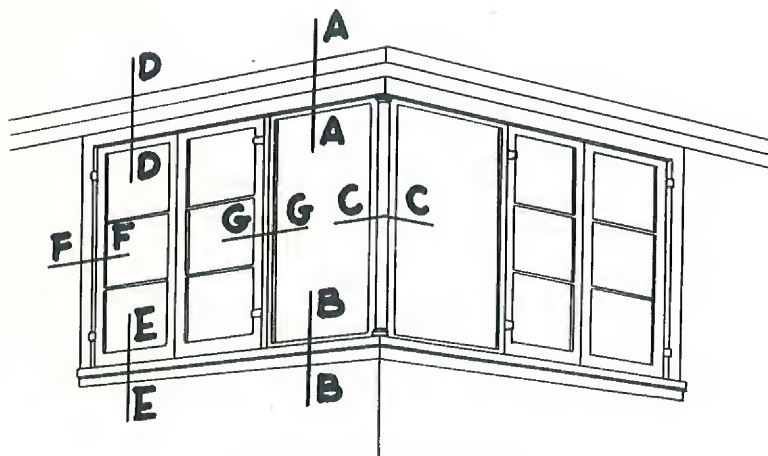
INSTALLATION DETAIL FOR PICTURE WINDOW EXTENDING
FROM FLOOR TO CEILING AND FROM WALL TO WALL
DETAIL SHOWS WOOD SILL



INSTALLATION DETAIL OF A CORNER PICTURE WINDOW



INSTALLATION DETAIL FOR A COMBINATION OF PICTURE WINDOW AND OPERATING SASH



INSTALLATION DETAILS

H-11

PC Glass Block Installation



The mason sets up glass block much as he sets brick or stone.

The installation of glass blocks or glass block panels is a regular mason's job, which should be handled on a regular contract or subcontract basis. Pittsburgh Corning Corporation does not itself accept installation contracts and acts only in a consultant capacity in connection with the installation of its products.

There are a number of special requirements which must be observed. They are laid up in straight rows, both vertically and horizontally, and without overlapping joints. In addition to mortar, several special materials are also required, including wall ties, expansion joints, calking materials and others.

Building code authorities throughout the country have accepted and approved the use of PC Glass Blocks as a building material of adequate strength for non-load-bearing construction when installed according to the manufacturer's recommendation. The Pittsburgh Corning Corporation maintains an able staff of field consultants and glass experts. Architects and engineers everywhere are invited to take full advantage of the co-operation and advice these men can extend in connection with problems involving these products. Complete engineering and specification service is provided on all Pittsburgh Corning products.

Glass block walls are always laid up as curtain walls, never as load-bearing walls. Provision must be made to accommodate differential expansion of the glass block panel and the other parts of the structure, and to this end, expansion joints must be provided at the jambs and heads of each panel. All sills upon which the glass block panel will rest must be coated with one of the several approved asphalt emulsions. Where roofers felt is used, the emulsion serves to adhere the felt to the sill. On the side jambs and head jambs, at expansion joints, the asphalt emulsion serves to cement the expansion strips to the adjacent construction during the erection of the glass blocks.

The asphalt emulsion may be applied readily with a brush, and should be applied as a heavy coat on sills. It should be allowed to dry for at least two hours before mortar is set. The emulsion must be applied with care so that it shall not be exposed to view after the completion of the panel. The emulsion is also used as an adhesive for applying roofers felt and expansion strips, which should be set in place while the emulsion is still tacky. Many brands of asphalt emulsion are approved by Pittsburgh Corning Corporation. A proper asphalt is available under PC label. Other brands also are available. Any brand which may be used should have the approval of the architect.

Expansion joint materials are required at the jambs and heads of each panel as shown in the installation details illustrated in this section.

Roofers felt must be used on sills of shear-lock bar construction. Any standard impregnated roofers felt in 15 or 20 pound weight may be used. It is available through building supply or roofing material suppliers.

The space between glass blocks and the sides of chase should be packed with lightly-oiled oakum. Heavily-oiled or tarred oakum, generally classified as plumbers oakum should not be used. The heavy oils or tar will bleed and stain adjacent materials.

PC wall anchors, size 1 $\frac{3}{4}$ inches by 21 inches, 20 gage perforated galvanized steel, are required as lateral support for panels subject to the limitations of panel sizes shown in this section. There is no other size or type of wall anchor available.

PC wall ties are available only as 2 inches wide galvanized wire mesh in standard 8 foot lengths. They are required in horizontal joints of all panels, spaced as shown at "B," "D," "J," "L" and "T" in "Details of Installation" on the following pages.

The perimeters of all exterior panels and all expansion joints should be calked with a knife or gun grade calking

compound in accordance with standard calking practice. The calking compound should be light in color, waterproof, and capable of making adequate and durable weather-tight adhesion to the glass blocks, as well as to well-cleaned surfaces of metal, concrete, brick, stone and other construction materials. Many satisfactory calking compounds are available, and the brand should first be approved by the architect.

A special type of mortar should be used in the installation of glass block panels. It should consist of one (1) part Portland cement, one (1) part lime, and four (4) parts sand all measured by dry volume, and an integral type waterproofer, mixed to a consistency as stiff as will permit good working. The mix must be drier than for use with ordinary clay brick. For interior partitions the waterproofer may be omitted. Setting accelerators and anti-freeze compounds must always be avoided.

At the discretion of the architect or supervising engineer, a mortar prepared from masonry cement of low volume change, incorporating metallic stearate type waterproofer, and mixed in accordance with manufacturers' recommendations, may be specified.

The integral type waterproofer specified in the preceding paragraph must be of the metallic stearate type and must be approved by the architect or supervising engineer. It should be added to the mortar at the time of mixing in the proportions recommended by the manufacturer. If a waterproof Portland cement or prepared masonry mortar is used, no further waterproofer need be added to the mix.

The cement, lime, and sand used should comply with the appropriate requirements of the American Society for Testing Materials—A.S.T.M. Designation C150-41, for cement; C6-31 or C5-26 for lime; and C144-41T for sand, except that not more than 12% of the sand by weight shall pass a No. 100 mesh sieve, and that 100% shall pass through a No. 8 mesh sieve as defined in the designation.

The contractor should furnish and install flashings in the locations shown on the drawings or wherever required or necessary to provide a complete installation.

In making an installation, the sills should be heavily coated with asphalt emulsion, which should be allowed to dry for at least two hours before mortar is placed. Expansion joint strips should be adhered to the jambs and head with asphalt emulsion, and should run continuously in the expansion space. They must rest directly on the sill.

All mortar joints must be completely filled with mortar and shall not be furrowed. Mortar must not bridge across expansion joints. Blocks are laid up plumb, true to line, and with one-quarter ($\frac{1}{4}$) inch^o visible width mortar joints. While mortar is still plastic and before final set, the joints should be compressed to a depth necessary to expose the corners of the blocks as sharp, clean lines. The joints should immediately be tooled slightly concave and smooth. The number of courses of glass blocks laid in successive lifts shall be limited to prevent compaction of joints.

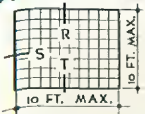
^oUnless otherwise specified.

CLEANING DURING INSTALLATION

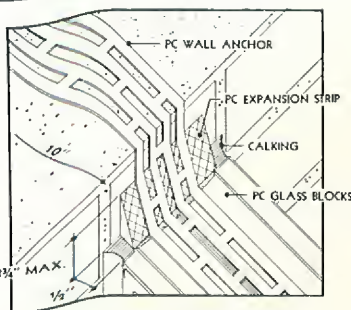
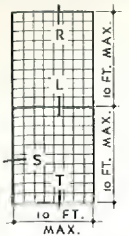
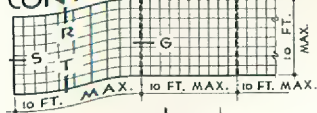
Excess mortar squeezed out of the joints should be removed by the mason as blocks are laid—the use of the recommended less moist mix will minimize "squeeze out"—but the glass will be smeared with a scum of cement, lime and water.

This scum is most easily removed if it is allowed to dry and is then wiped with a dry cloth (a wet cloth smears instead of cleans). By far the best time for cleaning is at the same time that the mortar joints are pointed and tooled—i.e., four to five hours after blocks are laid and prior to final set of mortar. Cleaning becomes increasingly difficult and

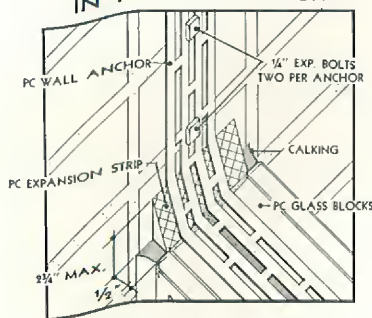
SIMPLE PANELS



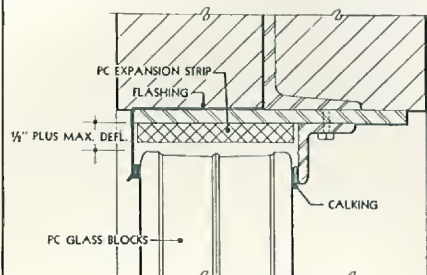
CONTINUOUS PANELS



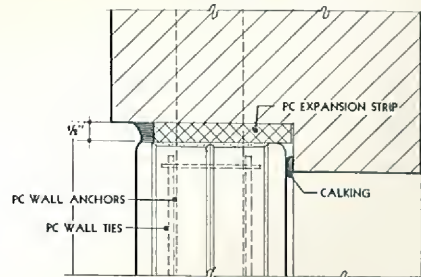
PC WALL ANCHORS IN NEW CONSTRUCTION



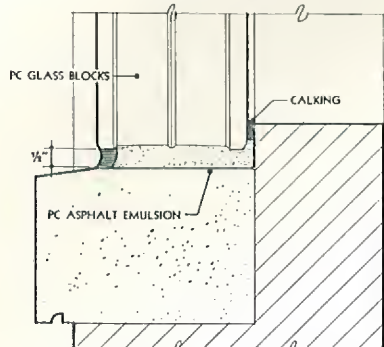
PC WALL ANCHORS IN EXISTING CONSTRUCTION



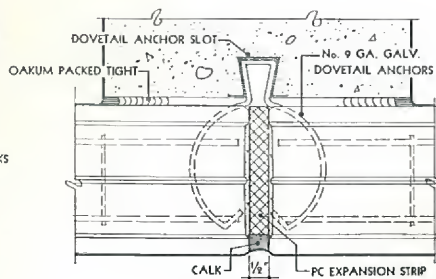
SECTION "R"



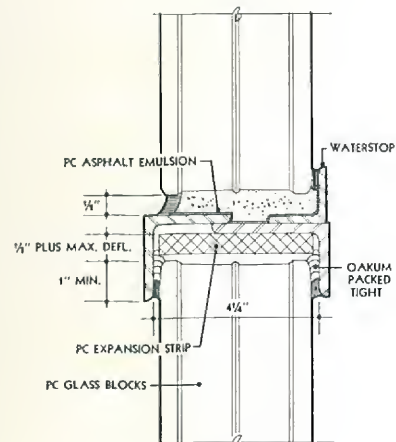
SECTION "S"



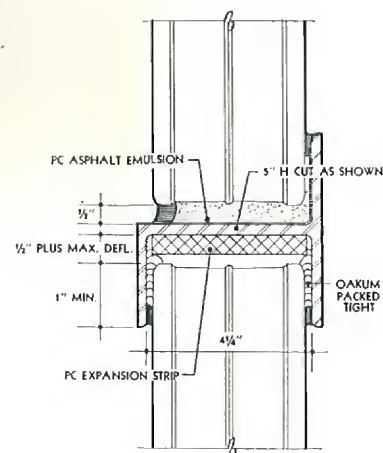
SECTION "T"



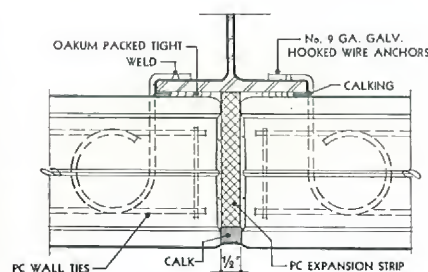
SECTION "G"



SECTION "L"



SECTION "L"



SECTION "G"

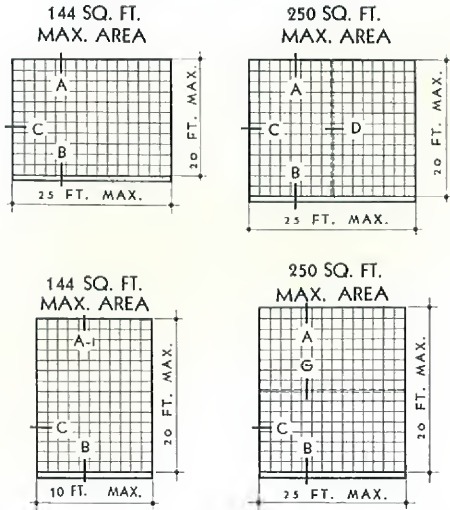
DETAILS OF INSTALLATION

costly as the mortar and scum harden after the final set. On special blocks having the roughened borders, and on any blocks where the scum has hardened, a stiff brush (a suede brush with bristles of bronze wire is good and can be purchased at five and ten-cent stores) or fine steel wool

will loosen the scum so that the block can be wiped clean with the dry cloth.

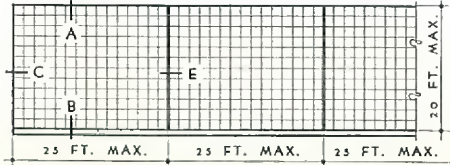
For final cleaning, the panels may be washed down with a 10% solution of muriatic (hydrochloric) acid followed by clear water to remove all traces of acid.

LARGE SIMPLE PANELS

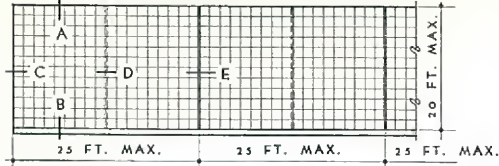


LARGE CONTINUOUS PANELS

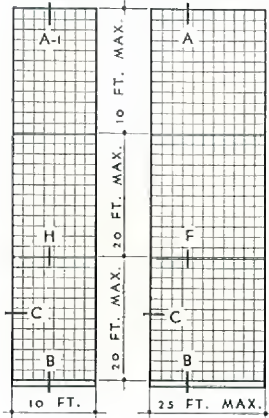
EACH PANEL 144 SQ. FT. MAX. AREA



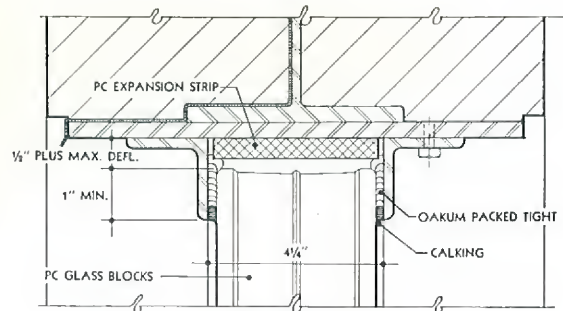
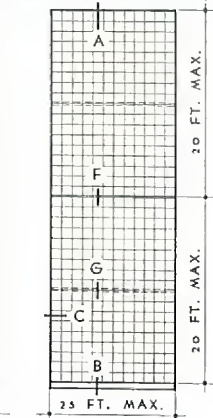
EACH PANEL 250 SQ. FT. MAX. AREA



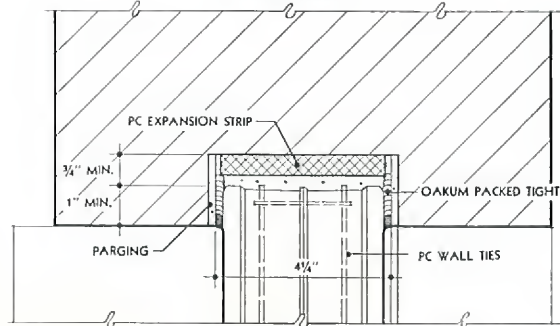
EACH PANEL 144 SQ. FT. MAX. AREA



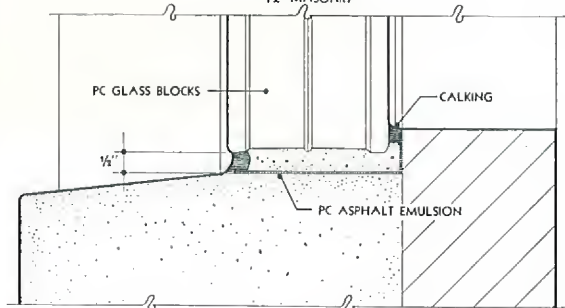
EACH PANEL 250 SQ. FT. MAX. AREA



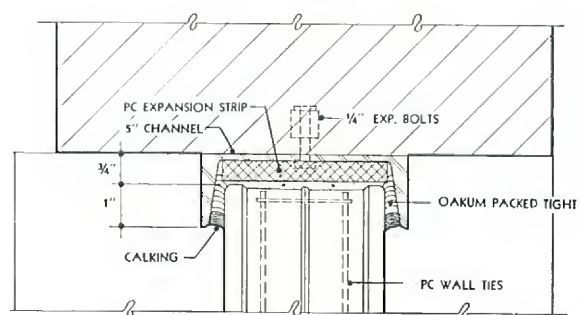
SECTION "A"
12" MASONRY



SECTION "C"
12" MASONRY

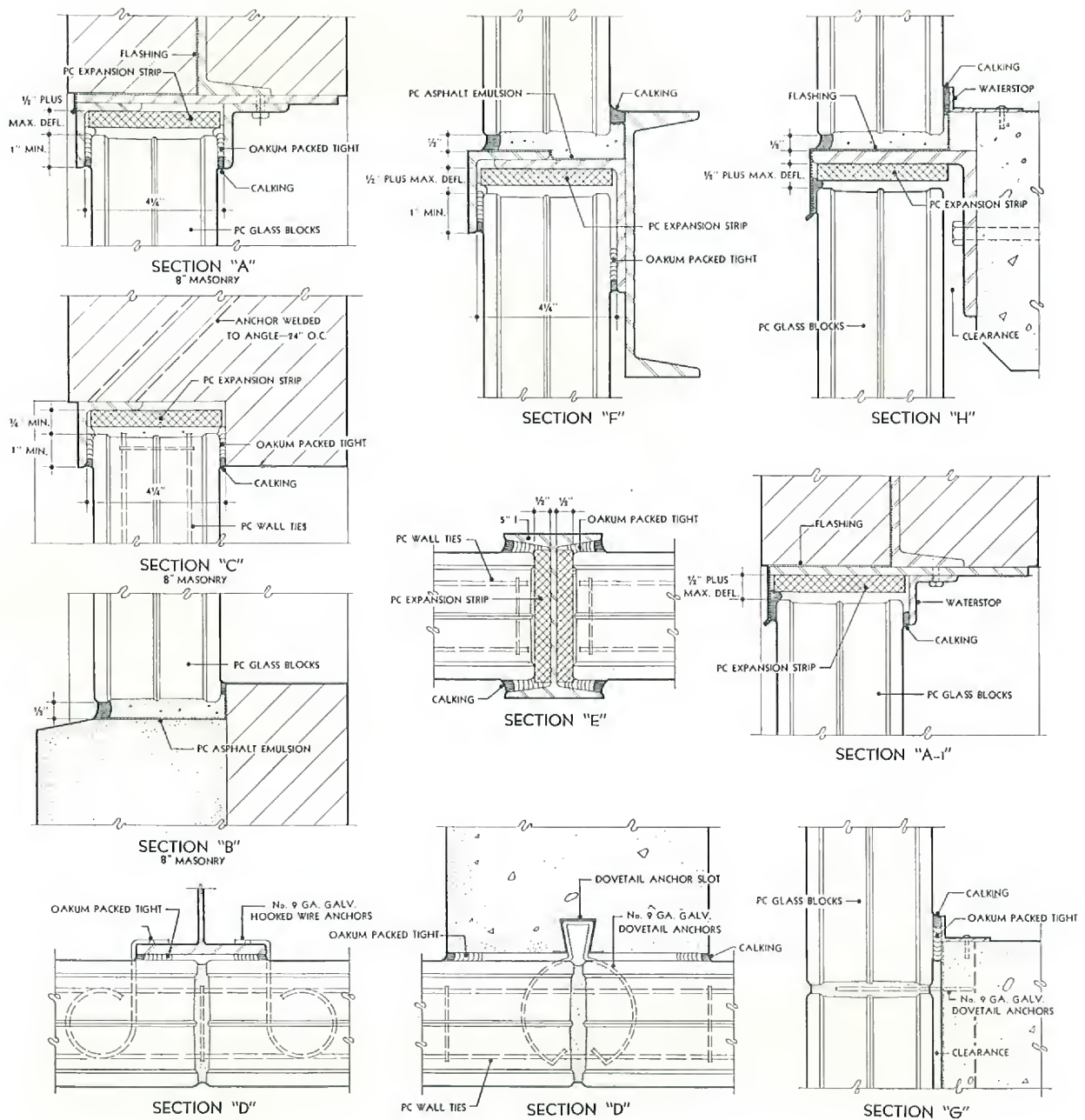


SECTION "B"
12" MASONRY



ALTERNATE SECTION "C"
8" OR 12" MASONRY

DETAILS OF INSTALLATION

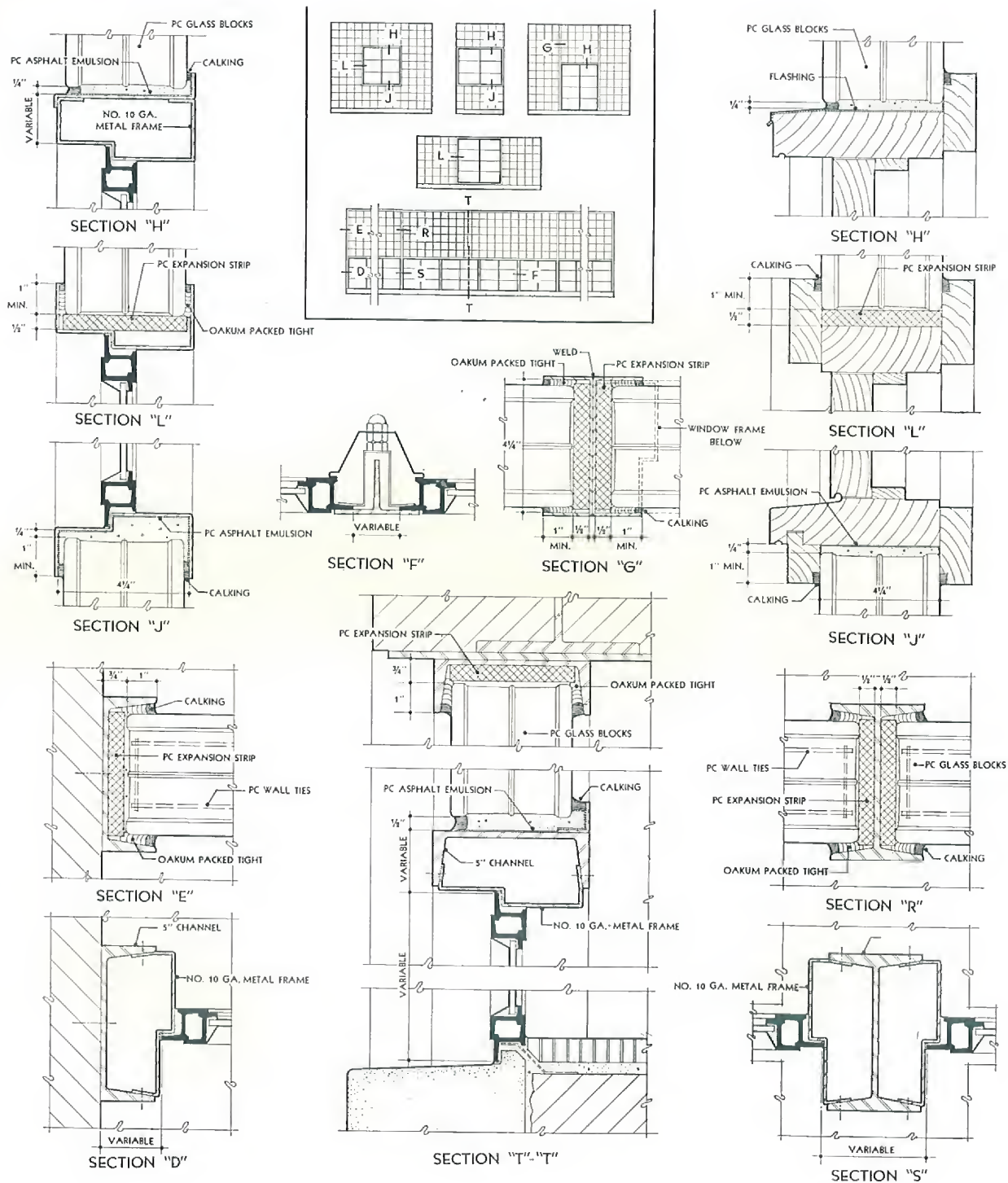


DETAILS OF INSTALLATION

MAINTENANCE CLEANING

To gain the full benefit of the uniformly high light transmission of PC glass blocks, panel cleaning at regular intervals is recommended. Although the period between necessary cleanings will be much longer with blocks than with

ordinary windows, local conditions should determine the frequency. Installations in food handling plants, hospitals and the like may be cleaned more frequently than those in other buildings, and Health Departments having jurisdiction often specify the manner of cleaning.



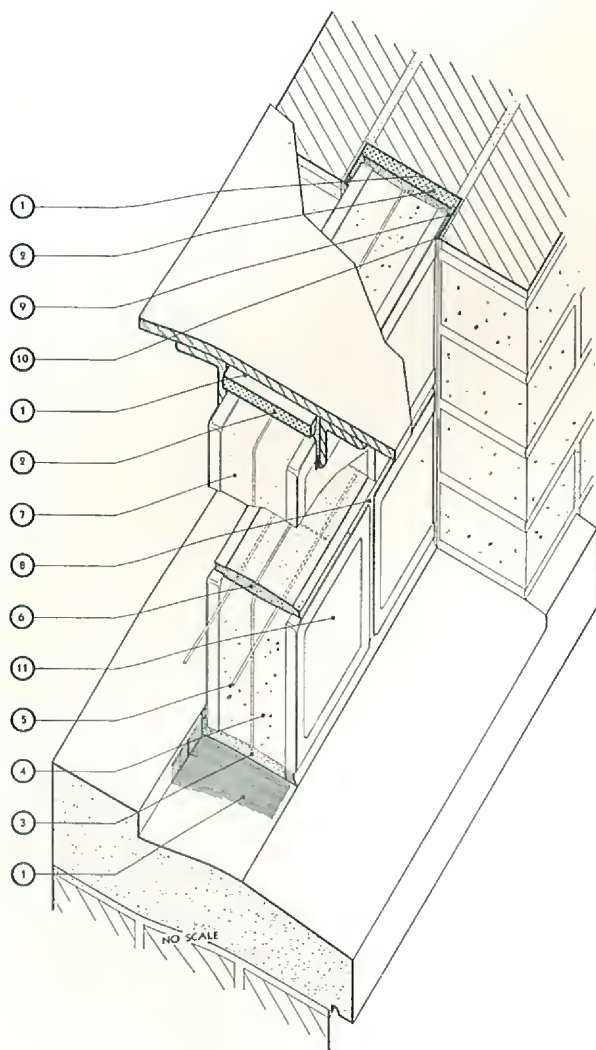
DETAILS OF INSTALLATION

The usual deposit of air-borne dust and dirt may easily be cleaned off glass block by wiping the panels with a damp cloth or brush. Where possible, most rapid cleaning can be done with a hose and a long-handled brush. If warm water is to be used on room surfaces of panels, it should never be hotter than 135°F. when the outdoor temperature

is below freezing, and it should never be above 160°F. In certain industries (bakeries, packing plants, etc.) where grease, fats or oil may be deposited on the panel surfaces, a solution of trisodium-phosphate—a standard cleaning material sold under many brand names—will be found effective. A recommended solution is 1/2 pound of "T-S-P"

in 12 gallons of water. Because this solution is strongly alkaline, glass should be rinsed with clear water after its use.

Where glass panels have stood for long periods, one year or more, without cleaning they should first be washed with the muriatic acid solution previously recommended to remove any chemical deposits on the glass surface. A clear water rinse should always follow acid cleaning to avoid damage to the mortar joints.



Ventilation may be provided in Glass Block panels, either by the use of sash or louvers as may be dictated by architectural design, type of installation or other factors. A variety of either type may be obtained, fabricated from metal or wood. Proper methods for installing sash units are illustrated in the construction details shown in this section. The manufacturers of louver ventilators describe proper methods of installation in their own literature.

HOW TO INSTALL PC GLASS BLOCKS

1. Mop entire perimeter of opening with heavy coat of asphalt emulsion.
2. Adhere PC expansion strip to jambs and head. Make certain expansion strip extends to sill.
3. Place full mortar bed at sill—do not furrow.
4. Set lower course of block. All vertical and horizontal mortar joints must be full and not furrowed. Steel tools must not be used to tap blocks into final position.
5. Place full mortar bed for joints not requiring wall ties—do not furrow.
6. Install PC wall ties in horizontal joints where required as follows:
 - (a) Place lower half of mortar bed. Do not furrow.
 - (b) Place wall tie centered in joint.
 - (c) Cover wall tie with upper half of mortar bed and trowel smooth. Do not furrow.
 - (d) Wall ties must run from end to end of panels and where used continuously must lap 6". Wall ties must not bridge expansion joints.
7. Follow instructions 3, 4 and 6 for setting succeeding courses of blocks.
8. Strike joints smoothly as shown while mortar is still plastic and before final set. At this time rake out all joints requiring caulking to a depth equal to the thickness of joint. Remove surplus mortar from faces of glass blocks and wipe dry.
9. After final mortar set, pack oakum (as specified) tightly into jamb and head construction as shown.
10. Calk interior and exterior perimeter of panel as shown with caulking compound as specified.
11. Final cleaning of glass block faces shall not be done until after final mortar set.

PC Foamglas Installation



Foamglas forms a substantial rigid base for a concrete load bearing floor.

FLOORS

Where normal temperatures are involved, floors laid directly on the ground are not usually insulated. However, in extreme conditions of temperature and humidity, it is desirable.

In this application, the floor surface should be reasonably smooth and level and without depressions. The floors should be clean and free from dirt and thoroughly dry.

Over all wood floors, a layer of rosin-sized paper or unsaturated felt should be applied. Over concrete floors, the felt is not necessary. The Foamglas should then be imbedded in a layer of hot asphalt laid progressively as the asphalt is mopped on the floor. When more than one layer is used, the additional layers should also be laid in the same manner. After the Foamglas is in place, a layer of fifteen pound asphalt saturated rag felt should be mopped over the Foamglas. A monolithic concrete floor never less than 3 inches thick should then be poured in place directly over the saturated felt.

Floor insulation is usually used in lumber drying kilns,

tobacco sweat rooms, research and testing laboratories, or any place where extreme temperature or humidity conditions occur.

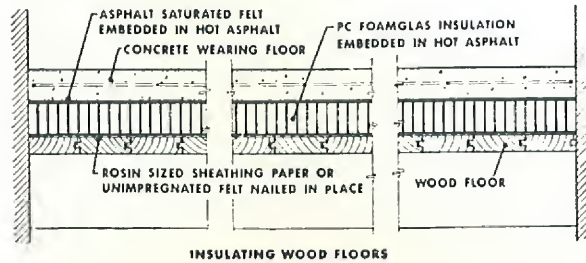
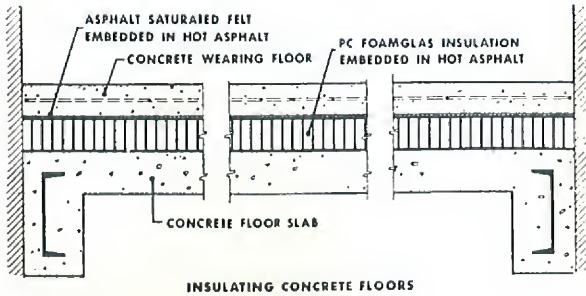
EQUIPMENT

Vertical and Horizontal Tanks and Towers Ducts and Breeching

In the process industries, it is necessary to insulate hot and cold equipment; practically all types in which any chemical processes take place.

Tanks and towers, both vertical and horizontal, are usually insulated by applying Foamglas blocks or circular segments directly to the face of the equipment to be insulated. It is then bound with steel bands or glass cloth depending upon the operating conditions.

Where steel bands are used, a layer of wire mesh is applied. Then the entire surface is finished with a fibrated emulsified asphalt such as Pittcote finish, if the equipment is



located out of doors. If the equipment is located indoors, it may be finished with any approved finishing cement.

When glass cloth is used as the banding on tanks and towers, it should be applied as a membrane against a good grade of asphalt cut-back mopped onto the Foamglas, and finished with a second coating of the same material.

Insulation of metal ducts and breeching is applied in the same manner as for tanks and towers except when it is desirable to have an air space between the surface of the duct and the insulation. In this case, a layer of reinforcing road-mesh is applied over the stiffener angles on the duct, and the insulation installed over the mesh.

On equipment where welding in the field is permitted, Foamglas can be applied easily by the use of the stud welder which is a system of automatically welding large headed pins which are pushed through the insulation and welded directly to the surface of the equipment.

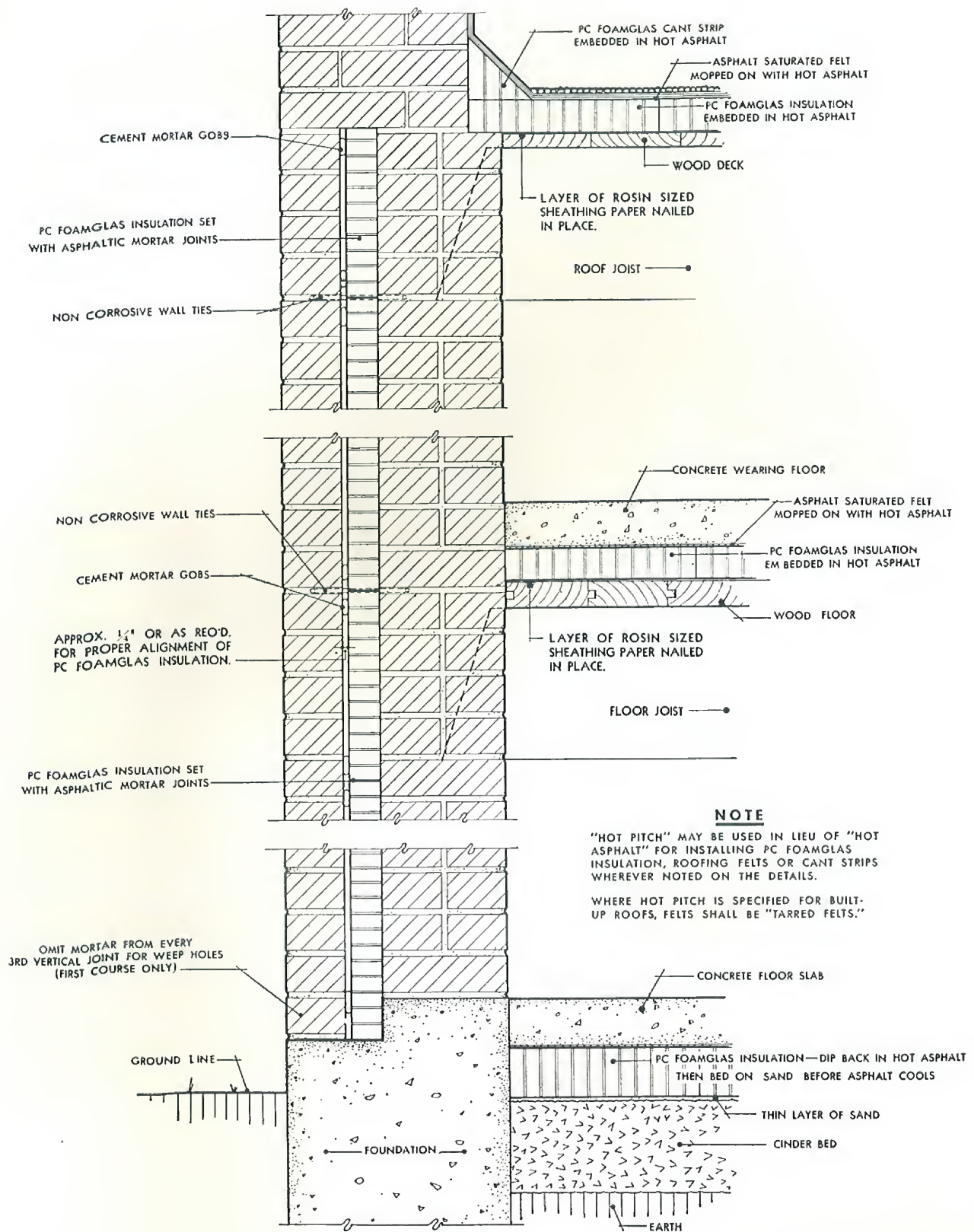
Tanks, towers, ducts, and so forth are usually insulated to prevent heat loss or heat gain; for temperature control, or employee's comfort or safety.

CORE WALL INSULATION

The insulation of walls is particularly important where ex-



Roof insulation with Foamglas is rapid, neat, and effective.



DETAILS OF FLOOR, CORE WALL, AND ROOF INSULATION

treme conditions of temperature or humidity are encountered.

The Foamglas is laid up as an integral part of the wall. It may be installed either on the inside or outside depending on the conditions.

After the inner or outer wall is laid up, the Foamglas is then applied directly against the face with asphalt mortar gobs, leaving a small air space between the face of the wall and the Foamglas. The Foamglas is set with asphaltic mortar joints, then coated with an asphaltic mortar back bed approximately one eighth of an inch thick or as required for proper alignment of the brick veneer or tile facing. Then the veneer wall which has little stability during erection will obtain additional support from the back bedding and wall ties which are spaced throughout, both in the original wall and the veneer, as required by the various building codes.

The specifications for this application may be varied to suit conditions. Another commonly used type of wall incorporates an interior veneer wall of Foamglas with considerably greater stability. This application does not leave any space between the Foamglas and the masonry walls. This is usually used where the inside surface of the exterior wall can be laid up plumb, level, and straight and where the interior wall surface does not necessarily need to be perfectly flush.

The accessory materials such as wall ties, asphaltic mortar, etc. will also vary depending on the various building codes.

The asphaltic mortar is generally a mixture of an asphalt emulsion, Portland cement, and fine, clean sand.

The wall ties may be made either of Z-shaped wire or corrugated metal strips. Foamglas should never be laid up with cement mortar or plastic of any kind. The core wall insulation is generally installed for the same purposes as the roof insulation.

ROOF INSULATION

As PC Foamglas is used only as insulation material, the established roofing practice should be followed in making the installation, both in the preparation of the deck and in the laying of the built-up roofing over it. The photographs illustrate an installation of a poured concrete slab roof. The slab should be clean and dry and the pitch should not be more than two inches in twelve. The deck should first be mopped with a uniform coat of hot pitch or asphalt (where asphalt is used, the concrete should first be primed).

The Foamglas insulation is firmly imbedded in the asphalt or pitch, laid with butted joints in parallel courses, with the joints in each course breaking with those of the adjoining courses.

After the Foamglas insulation is in place, it is mopped with a uniform coat of hot pitch or asphalt in small areas so that the built-up roofing can be laid on it immediately. The roofing is to be applied in accordance with the specifications of the roofing manufacturer.

Cant strips, sealing and flashing, are placed after the insulation is laid and before the finished roofing is applied. However, the completed insulation should be protected from the weather at all times.

The finished roof, insulated with PC Foamglas, provides better control of interior temperatures and humidities. It also improves working conditions and reduces heat losses and heat gains in air conditioned buildings.



Deck construction shall be clean, sound, dry and level. Mop deck with uniform coat of hot pitch. (Where asphalt is used, concrete should first be primed.) Mop only area on which insulation can be laid immediately.



Foamglas insulation shall be firmly imbedded in asphalt or pitch. All insulation shall be laid with tightly butted joints. Foamglas cannot be nailed in place. Lay insulation in parallel courses, with end joints in each course breaking with those of adjoining courses.



Cant strips and necessary sealing and flashing shall be completed after insulation is laid. Protect completed insulation from weather until finished roofing is applied.



Mop Foamglas insulation with uniform coat of hot pitch (or asphalt). Mop only area on which built-up roofing can immediately be laid. Built-up roofing shall be laid in accordance with best recommendations of the manufacturer of same.



The finished roof, using PC Foamglas as insulation, provides better control of interior temperatures, improves working conditions and reduces heating and air-conditioning costs. It eliminates damage to roof-deck construction resulting from rot and corrosion.

Special Installation Details

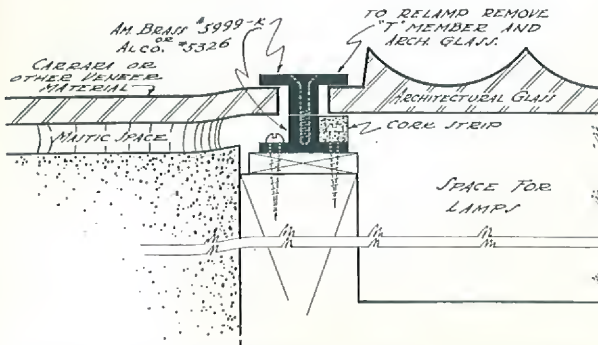
A few suggested Installation Details for Architectural Glass

ILLUSTRATING construction methods for various typical conditions encountered in decorative work. Standard metal sections or brake mold have been indicated so that they may be readily obtained as needed.

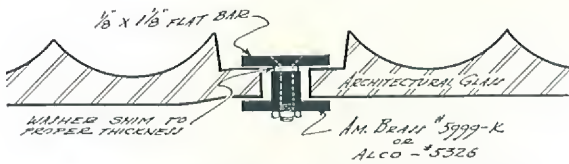
All joints and sections of glass surrounded by metal moldings should, on exterior work, be well caulked with plastic pointing compound, oakum, cork, felt or other serviceable material.

For best results never permit metal to fit TIGHT to glass. Thin strips of cork should be utilized as a cushion to permit expansion of the metal and prevent rattling in loose frames.

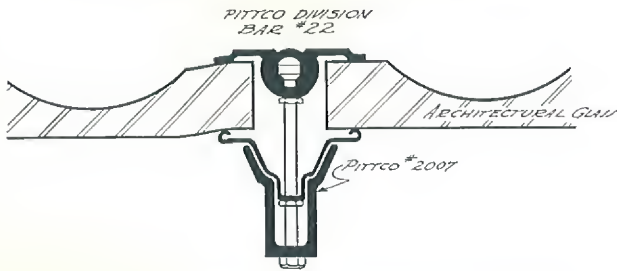
ARCHITECTURAL GLASS INSTALLATION DETAILS



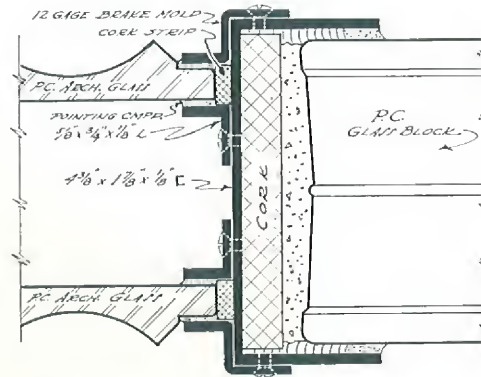
Architectural Glass adjoining Carrara Structural Glass or other veneer material.



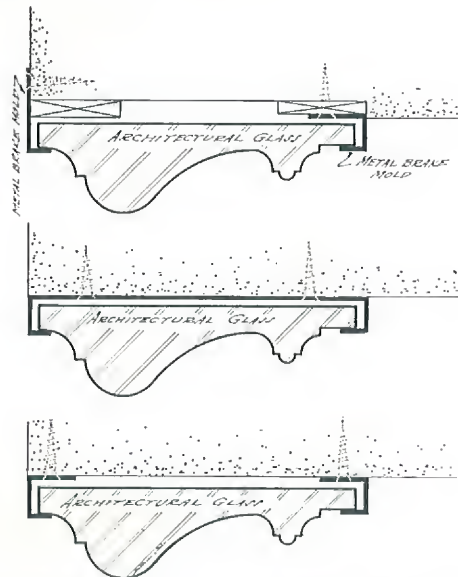
Metal separation for horizontal and vertical joints.



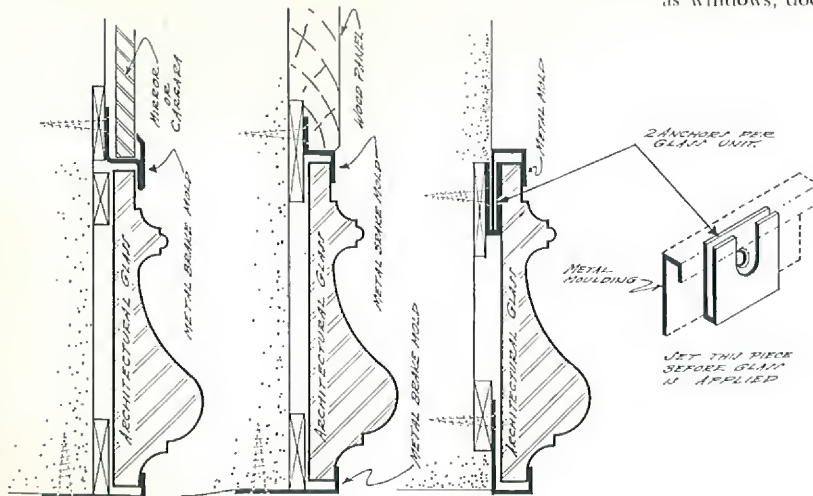
Vertical metal member capable of supporting wind loads.



Decorative use of Architectural Glass in a two-sided glass block wall.

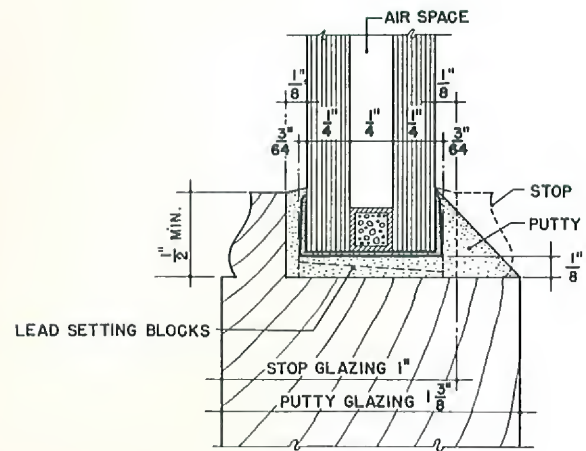
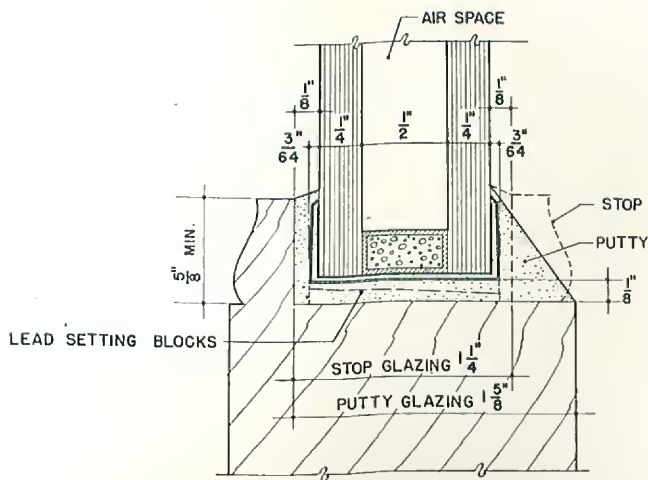


Suggested jamb sections of trim surrounding openings such as windows, doors, etc.

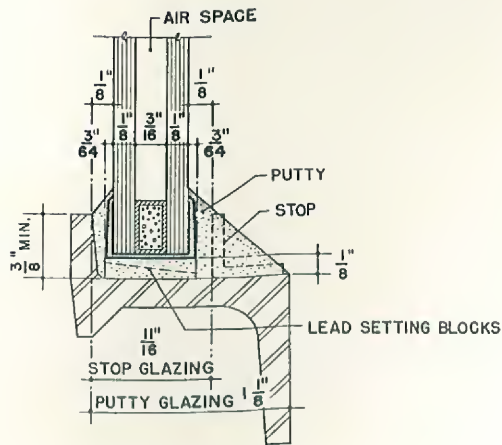


Suggested head sections of trim to be used in connection with jamb details.

DOUBLE GLAZED UNIT DETAILS



DOUBLE GLAZING IN WOOD SASH



DOUBLE GLAZING IN STEEL SASH

These details showing the installation of double glazed units illustrate the manner in which a double glazed unit should be installed. Note particularly that the putty should extend above the metal channel binding of the unit to make contact with the glass and provide a definite weather seal.

The drawings also illustrate how the desiccant is placed within the binding of the unit.

SECTION "I"

GENERAL INFORMATION

I-1

GENERAL NOTES

I-2

FEDERAL SPECIFICATIONS

I-3

COMPARABLE TRADE NAMES

I-4

GLASS CUTTING

I-5

VERSATILITY OF GLASS

GENERAL
INFORMATION

General Notes

A few unclassified items on glass, its properties, application and oddities

UNFORTUNATELY, there is absolutely nothing which can be done to restore the finish on a window on which soap has been allowed to remain even for several days under humid conditions.

The alkali in some soaps definitely attacks the surface of glass and etches it sufficiently so that its original brilliance cannot be restored by any amount of rubbing or other work which may be undertaken in the field.

This difficulty is particularly noticeable around the period of Halloween, but is also frequent when the opening of buildings is long delayed and the windows are marked up with soap to make them definitely noticeable to workmen.

Every possible effort should be made to discourage the use of soap as a marking material on windows, and if by any means possible, no marking should be resorted to.

In general, surgeon's adhesive tape, or other pressure-sensitive adhesive tapes, appear to be safe for use. Also, very thin films of ordinary white paint offer a satisfactory means for indicating the presence of glass, if not left too long.

An oil-type glass-frosting paint, which upon drying becomes translucent to opaque, seems to be a satisfactory obscuring or masking paint. Applied with a brush, it dries to the touch in about 4 hours, and dries hard in 12 to 24 hours. Aside from brush marks, it gives the glass a very satisfactory frosted appearance, comparable to a matt etch. A satisfactory marking paint may be prepared by mixing powdered chalk or whiting plus a small amount of wheat flour in water, and using as a water-color paint on the windows.

Never use any marking paint which contains glue or sodium silicate.

CHARACTERISTIC PATTERN IN HERCULITE (TEMPERED PLATE GLASS)

The heat treatment to which Herculite and

other tempered plate glass is subjected, results in a specific pattern in the glass which is not normally visible, but which may become quite marked under certain conditions of illumination. This pattern is characteristic of all tempered glass and cannot be considered in any sense a defect, nor can any replacements be made on that account. The replacement glass would show the same characteristic pattern under the same conditions of lighting.

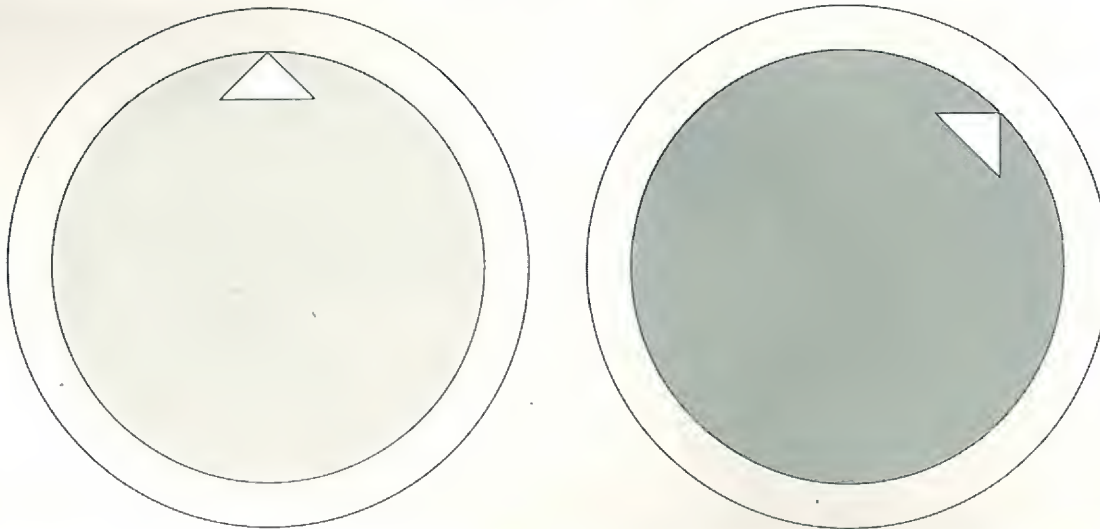
The pattern often appears as an iridescent effect, more or less in checkerboard or link chain pattern. Its visibility results from the transmission or reflection of polarized light, which is normally present in the light from a clear sky, or in sunlight striking the glass at the necessary polarizing angle. It will be especially and always visible if the observer wears Polaroid spectacles, since those spectacles permit only polarized light to pass, and tempered glass acts as a partial polarizer. Under these conditions, the observer may think that the glass is not thoroughly clean. Nothing can be done to eliminate this effect when the lighting conditions are proper for developing it. The pattern is positive confirmation that the glass is properly tempered.

POLARIZED LIGHT

Polarized light is ordinarily described in most elementary handbooks or textbooks on Physics. A polarizer limits the path of light rays reflected from it, or passing through it. Certain types of chemical compounds and crystals have the property of polarizing light.

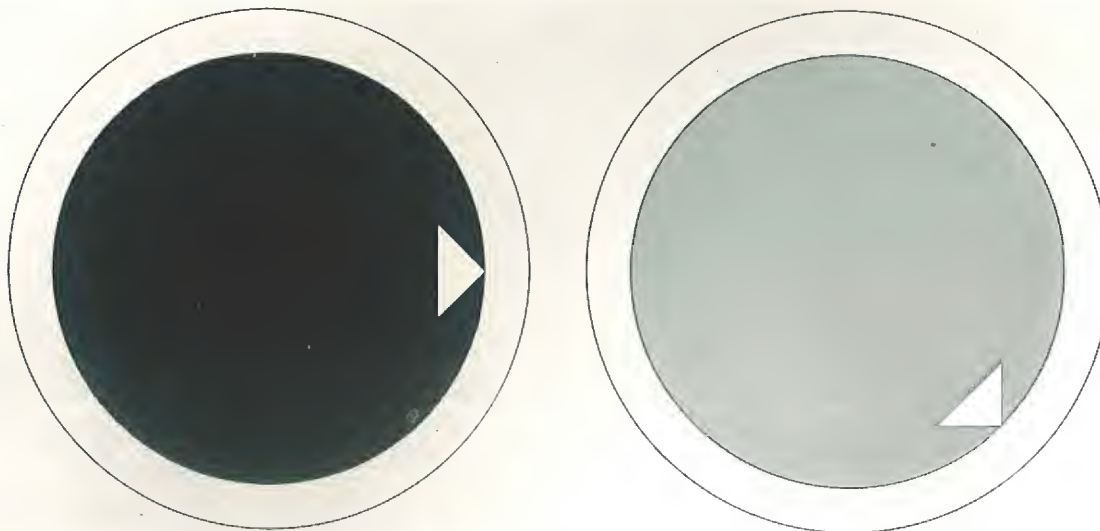
When two polarizers are placed so that the plane of polarization of one is at 90 degrees to the plane of polarization of the other, the system is said to be closed, and no light will pass through the system. When they are placed so that their planes of polarization are parallel, the system is

AN ILLUSTRATION OF THE MECHANICS OF POLARIZATION



TWO SUPERPOSED POLARIZING DISCS (bottom plate remaining stationary)

System open—planes of polarization parallel to each other—maximum light transmission. Top plate rotated 45° — planes of polarization at 45° to each other — 50% of maximum light transmission — system half open.



Top plate rotated 90° —planes of polarization at 90° to each other—no light transmission. System closed—top plate rotated 135° —planes of polarization at 45° to each other—50% of maximum light transmission—system half open.

said to be open, and a maximum of light may be allowed to pass.

POLARIZED GLASS

Polarized glass, an integral product, is nonexistent. There is not known any material which will retain its properties of polarizing light after being incorporated into a glass melt. However, within the last few years, there has been developed a process for producing reasonably large

plastic sheets incorporating a polarizing material and which may be laminated between two pieces of glass by the usual safety glass lamination processes to produce a very satisfactory polarizing medium. This material, known as Polaroid, consists of very fine crystals of a polarizing substance widely dispersed in a plastic film in such a way that the crystals are all parallel, one to another. The resultant product is a polarizer of great merit. When two sheets of this material are properly

placed together, complete interception of light is achieved and consequent darkness results on that side of the system away from the light source. Now, if a sheet of cellophane be placed between the two sheets of Polaroid, and turned slowly, relative to the two plates of Polaroid, the system may be opened or closed at will. This same opening or closing of the system may be achieved by rotating the plates themselves relative to each other. This material will transmit somewhat less than 50 per cent of normal white light and somewhat less than 90 per cent of plane polarized light.

GLAZING LAMINATED SAFETY GLASS†

In any case where laminated safety glass of any type is used in windows, certain very definite precautions must be observed in order to make a satisfactory installation.

A knife-grade putty with the least possible amount of linseed oil in it should always be used, even though the effort of working such putty in cold weather may be materially greater than would be the case with a softer putty.

In any case where the oil in the putty can come in contact with the plastic itself or with the caulking compound in those glasses which are caulked, the oils of the putty bleed into the caulking or into the plastic and cause discoloration and occasionally separation or shrinkage. In the instances where caulking compounds are not used, the bleeding of the oil into the plastic causes unsightly discoloration to penetrate very deep into the plate, such that reglazing would presumably be necessitated.

Laminated safety glass of any kind should be protected with a piece of *Scotch Cellulose Tape stretched along the edges and slightly overlapping the faces of the glass.

In every instance the glazing putty should extend against the faces of the glass sufficiently above the edges of the sealing tape to provide an adequate and satisfactory weather seal.

†Conclusions resulting from a long series of tests conducted at the Duplate Laboratory.

*Scotch Cellulose Tape, sold by Minnesota Mining & Mfg. Co., St. Paul, Minnesota.

THE PAINTING OF DISPLAY WINDOWS

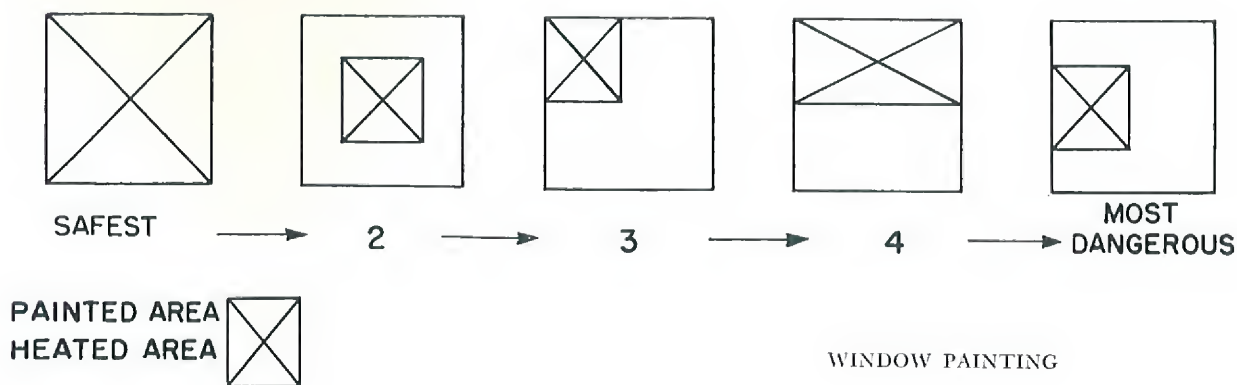
In many instances, glass which has been painted has broken. The effects of painting have been extensively investigated, with the following conclusions.

The most dangerous exposure is the southern exposure, the next most dangerous is the western exposure, the least dangerous is the eastern exposure where direct sunlight is concerned. Since there is no direct sunlight, there should seldom, if ever, be any breakage from the painting of windows on northern exposures.

The effects are emphasized where the glass is held rigidly in a frame and cannot expand or contract with changing conditions.

Windows which are painted with any type of opaque paint, and particularly with opaque black paint, are especially subject to breakage under direct solar exposure.

It is dangerous to paint any appreciable area of plate glass or other glass window with any completely opaque paint, quite irrespective of the amount of area of the window which such painting may cover. It is particularly dangerous to paint valances across the top of a pane since this is the second most dangerous condition which can exist. The most dangerous condition is to paint across the top of a pane a valance which does not reach entirely to the edges, while extending reasonably into the window. An area which approximates



one-quarter of the total area of the window, or more, and extending in from the edge of the window to approximately half of the depth of the window, is quite the most dangerous type of painting which can be done.

It is least dangerous to paint the entire area of the window or the central area of the window, not in excess of 25 per cent of the total area.

Most of the plate glass insurance companies are advised of these conditions and most of them will impose a larger premium, if they will accept the risk at all.

White paint, or very light-colored paints, are less likely to cause breakage than are the darker and more absorptive paints, but the application of valances, borders, or similar painted areas, to glass may be expected to cause breakage, especially on southern exposures.

A very thin coat of lamp black suspended in shellac, which permits the greater portion of the solar light and heat to penetrate, while at the same time preventing the possibility of seeing into the building through the glass, seems safe to use. It is essential that the greater portion of the solar light and heat shall be able to penetrate through any coating which is put over the glass, if the glass is to be maintained without breakage.

ULTRA-VIOLET RAY TRANSMITTING GLASS

The subject of ultra-violet ray transmitting glass is resurrected from time to time and given publicity, often quite misleading, especially in relation to residential glazing. The result is a flow of inquiries to glass manufacturers for detailed information and prices. The purpose of this article is to eliminate some of the confusion in connection with the use of ultra-violet transmitting glass.

The most effective therapeutic wave length is 302 millimicrons, and it is for this reason that a Federal Specification covering ultra-violet transmitting glass is entitled: "Glass; Flat, Glazing (for) Transmitting Not Less than 25% of Ultra-Violet Radiation at Wave Length 302 Millimicrons."

None of the regular window glass or plate glass products generally available (not even Crystalex) will meet the requirements of the specification mentioned above.

The upper limit of wave lengths possessing therapeutic qualities is about 313 millimicrons, but widely known glazing materials will not trans-

mit a significant amount of ultra-violet of any wave length shorter than 313 millimicrons.

Most of the regular glasses will transmit a large proportion, more than 80 per cent in some instances, of the longer ultra-violet waves. These transmitted waves, which lie between the upper limit of the therapeutic range at about 313 millimicrons and the lower limit of the visible spectrum at about 405 millimicrons, comprise a relatively wide band of ultra-violet radiations which are more active photochemically than visible or infra-red wave lengths, but which are ineffectual from a therapeutic standpoint. Glass vendors who are unfamiliar with, or heedless of the facts, have sometimes permitted customers to purchase glass on the basis of this high percentage transmission of impotent ultra-violet light. The customer's expectation of benefits to be derived from the health-giving sunlight transmitted by such glass is based upon insufficient information.

Although certain special glass will transmit 25 per cent or more of therapeutic ultra-violet and has a very definite and valuable utility when glazed into solaria, its value for ordinary glazing in windows of typical residential or public buildings is doubtful. Even in solaria, the special glass must be kept scrupulously clean since a very slight accumulation of dust or soot will materially reduce the ultra-violet transmission.

The following quotation from pages 683, 684, and 685 of Bureau of Standards research paper No. 113 entitled "Data on Ultra-Violet Solar Radiation and the Solarization of Window Materials" is pertinent and may clarify previously gained impressions:

"If, in addition to atmospheric absorption, the rays must pass through a glass which transmits only 25 to 30 per cent of these rays (or less than about 0.0001 g. cal. through a north window) the intensity appears to be close to the threshold value for therapeutic purposes. This conclusion follows from the observations of Tisdall and Brown, who obtained practically no healing effects from the light of the sky at a distance of 3 feet or more from an average-sized window, under conditions similar to those found in the average home.

"Their observations, which were made in August, show that in the latitude of Toronto (43.6°) the light of the sky shining through an ordinary-sized window, whether glazed with special glass or covered with ordinary fly screen, had practically no effect in preventing rickets in

animals except immediately adjacent to the window (that is, an exposure to the whole sky), and that in order to obtain real benefit it is necessary to receive the direct rays from the sun. Furthermore, they found that, while during the winter months (December, January and February) the ultra-violet rays produced a slight, but definite antirachitic effect (which was only about one-eighth as great as in April and May), the use of special window glasses in that locality during the winter months is probably of little value. As is to be expected, their work shows that in order to obtain a useful antirachitic effect from sky shine (that is, solar rays reflected from the sky and clouds) approximately equal to that of the direct rays of the sun, it is necessary to construct a solarium of special glass which will admit rays from a large part of the sky."

"The most recent and important data, which, no doubt, will settle the question of placing windows of special glass on the north side of school and office buildings, were published by Clark. The observations were made in a large room on the seventh floor with a north exposure. During perfectly clear days, at noon, in March and April when the illumination from the hemisphere of north sky incident upon the window sill was approximately 400 foot candles (in good agreement with the measurements of Kimball and Hand, already mentioned), the illumination in the center of the room, 5 m. from the window was 10 foot candles. The conclusion was that if the room were equipped with ultra-violet transmitting glass windows, a child, located in the center of the room, would have to sit there for 20 hours in order to obtain as much ultra-violet radiation as it would receive in two minutes out of doors in sunlight at the noon hour. In May, it would be necessary to sit there for 15 hours in order to get the equivalent of two minutes of direct noon sunlight. But since only during 5 to 6 hours at midday an appreciable amount of ultra-violet is transmitted

through the atmosphere, it would be necessary to sit for 3 days to obtain the benefit of two minutes of direct noon sunlight. The usefulness of such glasses in solariums is admitted, but Doctor Clark states that a better solution of the problem is to get out of the schoolroom and the office at the noon hour.

"Further evidence supporting these conclusions was recently published by Eddy who found that, in order to prevent rickets, the animals under test had to be kept directly in the path of the sun's rays. Those animals that were 1 m. or more from the window, or close to the window, but outside the path of the sun's rays, developed rickets.

"All the evidence available at present indicates that for the treatment of invalids a solarium glazed with special window glass is necessary in order to obtain beneficial results in preventing rickets and presumably for general therapeutic purposes.

"In connection with the foregoing discussion, it is relevant to include data on the use of heavy, wired glass, which is of importance for safety in the case of breakage, when used on a sloping roof. From calculation on samples of glass which, for a thickness of 2.3 mm., transmit only 20 to 30 per cent, and from direct observations it is found that thick (6 mm., one-fourth inch wired) samples of this type of glass transmit only 3 to 5 per cent at 302 *mu*. In a previous communication it was shown that this transmission is too low for biological use. Hence, if thick samples must be used, for safety, then it is necessary to use material that has little or no absorption at 302 *mu*. Otherwise, it will be necessary to use single thickness (2.3 mm. = 0.09 inch) glass backed with a 1 cm. wire mesh which shuts out about 10 per cent of the total light."

It is hoped that this discussion and citation will provide a better basis for evaluating the use of ultra-violet ray transmitting glass than has been readily available heretofore.

Glasses transmitting appreciable percentages of therapeutic ultra-violet are not widely manufactured. Although there are quite a number of such glasses made in small sizes which have an important place in scientific work and certain special applications, there appears to be only one domestic source of supply for a glass of this type which is suitable for glazing purposes.

RADIANT ENERGY

A chart of radiation will be found on Page 2 of Section J-1 which illustrates all the relative wave lengths of radiant energy, whether emanating from the sun or from man-made sources. This chart covers the range of radiant energy from .01 millimicrons wave length up to 1000 meters wave length and includes X-rays, extreme ultra-violet, ultra-violet, the visible spectrum, infra-red, many known but little used electrical radiations and the common radio broadcast bands.

That part of the spectrum including the extreme

ultra-violet and the near infra-red has been expanded to illustrate more clearly the separations of energy and particularly that part which affects the human eye or other parts of the human body. Ultra-violet extends into the short wave lengths from 4000 angstroms downwardly. The visible spectrum extends from 4000 angstroms in increasing wave lengths up to and including 800 angstroms while the infra-red or so-called heat energy extends from 8000 angstroms on upwardly, to approximately 1,000,000 angstroms.

Why is Glass Transparent?

An Explanation of the Phenomenon of Transparency

LIGHT can be explained in many respects by the fact that space has the property of carrying electric and magnetic forces that vary periodically with time. The whole phenomenon is known as an electromagnetic light wave. Matter influences this periodically varying field through the charged particles of which matter is composed. The particles of matter are moved by the electrical forces of the field.

Visible light has a wave length of from 0.4 to 0.7 μ . The formula $c = \lambda \nu$ ($c = 3 \times 10^{10}$ cm./sec., λ = wave length, and ν = frequency) shows that the vibration frequency is extremely high, namely of the order of 10^{14} per sec. Now electrons are light enough to follow these extremely quick varying fields if the electrons are free to move and not bound by atomic forces to the heavy positively charged nuclei of the atoms. The nuclei are some 2000 times heavier than the electrons. Such free electrons are found in metals. They move inside a metal like gas particles with high velocities that are due to the heat motion and cause the high electric conductivity of metals. If light strikes a metal these free electrons start to swing in phase with the light vibration and convert the electrical energy into mechanical energy of motion and finally into heat energy. Therefore metals are not transparent—at least in thick layers.

From this picture it follows that substances having high electrical conductivity, that is, having free electrons, should be opaque, whereas insulators should be transparent. Examples are the metals that are opaque. Another example is diamond and graphite. Diamond is transparent and an insulator. Graphite is opaque and a conductor. All organic liquids are transparent and insulators. Water is transparent and an insulator. Of course, liquids can acquire some small conductivity and yet be transparent. But this conductivity is ionic in origin. This explains why glass in heating does

not become opaque, as the conductivity of glass acquired by heating is ionic and not electronic in character. If a metal becomes part of a compound, its free electrons are bound to the radical with which the metal is compounded and the compound is transparent. For example, CuSO_4 (copper sulfate) or lead glass. In the latter the lead is present as a lead compound.

On the other hand, there are many insulators that are opaque, as for instance, ceramics. This is explained by the grain structure of these substances that are composed of grains of different indices of refraction. That is, these substances are not strictly homogeneous and multiple reflections at the grain boundaries prevent light from passing through. Another example is sintered glass.

The explanation given here for opacity as due to absorption by free electrons applies only to the visible part of the spectrum.

In the infra-red region light waves are capable of inciting the whole molecular structure, including the nuclei, to vibration and rotation. The variety of these motions is very great and therefore many absorption bands may occur, or even a continuous absorption may take place.

In the ultra-violet region the electrons in the outer electronic shells are lifted into higher energy levels. The whole subject is governed by the laws of quantum mechanics.

In the X-ray region the particle properties of light are more apparent and absorption is chiefly a function of the nuclei contained in the glass. The heavier these nuclei are the more absorption takes place. Lead glass, for instance, absorbs more than common silica glass.

Conclusion: Glass is transparent for visible light because it is a homogeneous insulator and has no free electrons.

Items of Personnel Interest

Safety, Insurance and Retirement

THE SAFETY DEPARTMENT

Always, in handling glass, it is especially desirable to follow the safety precautions which are advocated by the Safety Department of the Company. Among these requirements are special metal studded wrist guards or wristlets, soft flexible leather hand pads, and metal toe guards. Metal studded aprons and eye-protective goggles are required equipment in glass fabricating and cutting, in addition to the items just enumerated. In some of the processes, as in sandblasting booths, respirator masks are a part of the prescribed equipment, and where prolonged or severe exposure to sand dust is probable, a complete uniform much like a deep-sea diving suit must be worn as required equipment.

The Safety Department maintains a careful co-operative supervision over the various Company activities throughout the factories, warehouses and stores. Its recommendations are based upon careful studies of all the conditions, and are intended always to be mutually helpful as well to the workman on the job as to the manager in his office. There is an old adage that familiarity breeds contempt, which may be interpreted to mean that familiarity with a job leads to carelessness—and carelessness leads to accidents. Accidents are usually unnecessary, and are always costly in health, time, materials and money. Observance of the safety precautions will prevent the occurrence of accidents.

GROUP LIFE INSURANCE

A plan of group life insurance is available, underwritten by the Equitable Life Assurance Society of the United States. Under this plan no dependents are required and it contains no restrictions as to who may be beneficiaries. This plan is contributory, the Company assuming all costs over and above the nominal cost to the insured of \$.60 per month per \$1,000 of insurance.

DETAILS OF THE PLAN

ELIGIBILITY: All employees who have been continuously in the employ of the Company for six

months are eligible for the insurance.

MEDICAL EXAMINATION: No medical examination is required of employees who subscribe for the insurance within thirty-one (31) days following the date of eligibility. Any eligible employee who does not apply for the insurance within the thirty-one (31) day period can enter the plan only by submitting to a medical examination satisfactory to the Equitable. Such examination will be at the employee's own expense.

Additional information in booklet form may be obtained from the Insurance Department at the General Office.

RETIREMENT PLAN

Since December 24, 1940, a Retirement Plan for Employees has been in effect. Membership in this Plan was available only to certain employees earning over \$3000 per year. Effective December 24, 1945, the Plan was amended to provide greater benefits for employees upon retirement. Membership in the amended Plan is available to salaried employees provided they have completed three

years of continuous employment with the Company and have attained age 30 and have not attained age 65.

The Plan is underwritten by the Equitable Life Assurance Society of the United States. A descriptive booklet outlining the cost and benefits of the Plan may be obtained from the Insurance Department at the General Office.

Architectural Relations

General

In the construction industry the architect holds a pre-eminent position along with the engineer and designer in the planning of buildings of every description.

The architect not only designs the building, but also designates the materials of construction. He carries responsibility for the selection of the type of material to be used and is therefore deeply concerned in the merits of products, their adaptability and application.

To meet the needs of architects for technical data and practical uses of its products, Pittsburgh Plate Glass Company maintains a corps of specialized experts in strategic locations whose services are devoted to introducing new products and disseminating information covering all Company materials.

Each man of the Department of Architectural Relations is trained with meticulous care in the

study of the performance of Company products and their uses in building construction, to act as liaison between the architect as the builder and the Company as the manufacturer.

He is available in the architect's drafting room to co-operate on problems of detail, suggest specifications and proper methods of installation.

The principal objective of the department is to ensure that when the architect specifies Pittsburgh Plate Glass Company products he assures himself and his client that materials of merit will be used and performance guaranteed by the reputation of the manufacturer.

The Company representative is equipped to furnish the architect with technical data, descriptive literature, full-size details, samples, etc., of all the diversified Company products, including drawings or photographs of material installations and model specifications covering paint and glass.

ARCHITECTS SAMPLES CORPORATION

A most comprehensive permanent exhibit of building materials under the supervision of Architects Samples Corporation is maintained on the ground floor of the Architects Building, 101 Park Avenue, New York City. Here architects, engineers, designers and builders may inspect products of construction and at their leisure become acquainted with their uses and application from practical actual-size models.

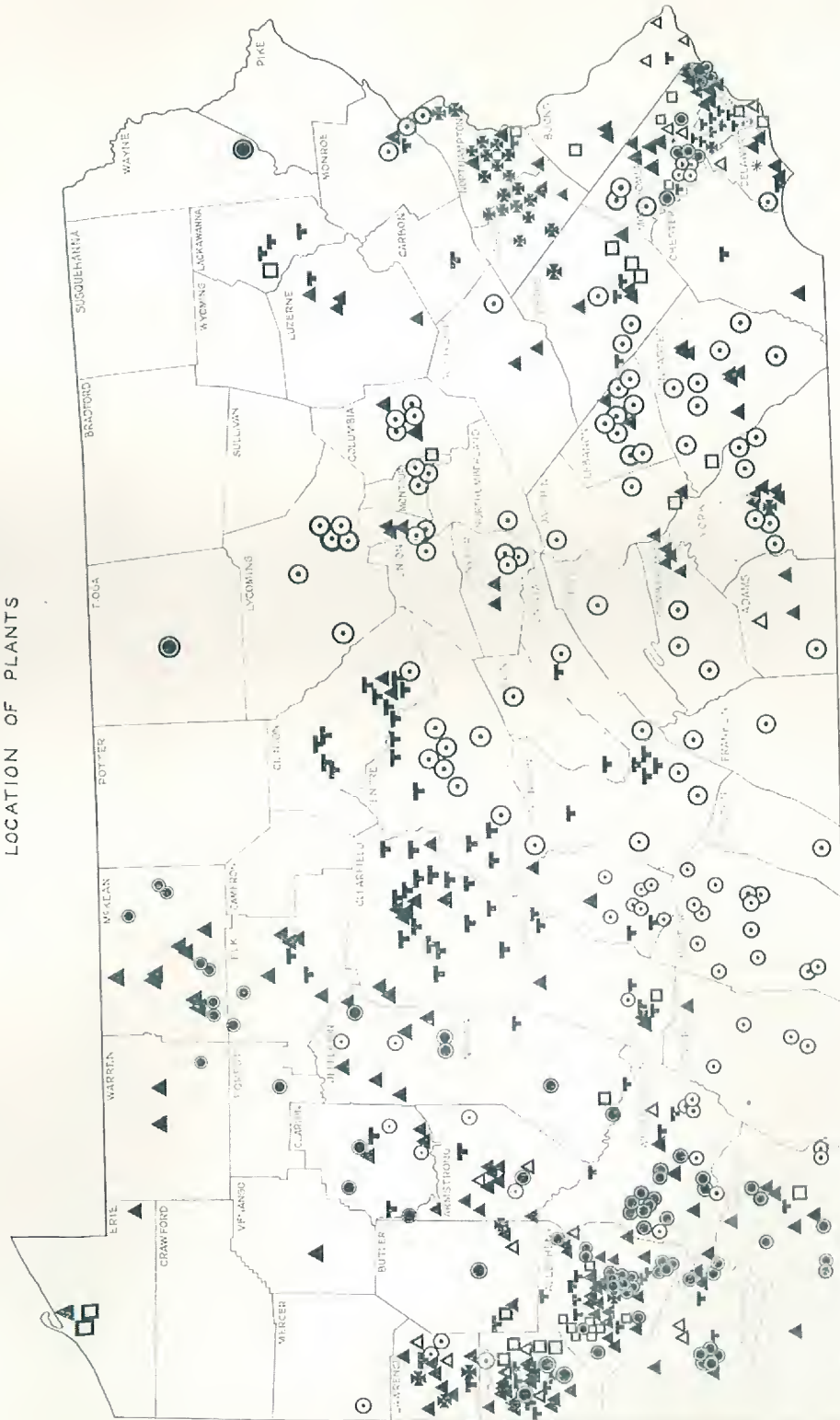
The building, which is strategically located in the heart of the great metropolis, covers two-thirds of a city block and is the center of professional architectural activity. It houses more than one hundred forty architectural firms engaging well over one thousand active architects, engineers and building contractors.

The displays, installed and maintained by the manufacturers, embrace the full gamut of construction materials and building equipment, enabling the architect to show his client the actual materials to be used under his specifications.

The Pittsburgh Plate Glass Company for many years has shown its products here in a large and conspicuous exhibit which comprises all its construction materials, regular and special glasses, mirrors, glass blocks and Foamglas, Pitco store front models and Carrara installations. The Company paint products are shown in a full line of color panels, illuminated color miniature transparencies showing schemes for painting and decorating both exterior and interior. The display is comprehensive and thoroughly instructive.

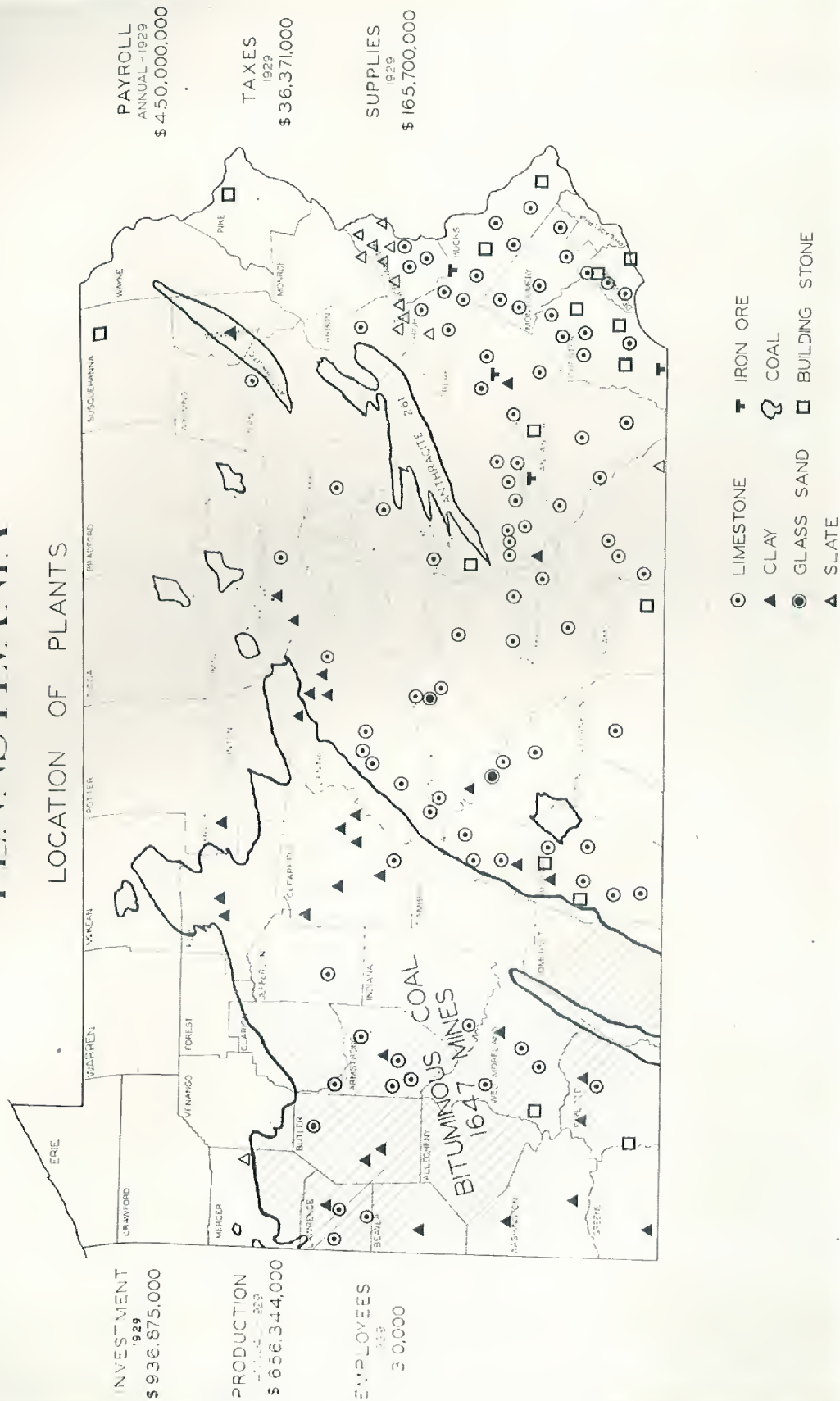
CERAMIC INDUSTRIES OF PENNSYLVANIA

LOCATION OF PLANTS



- | | | | |
|---------------------|---|--------------|---|
| CEMENT | ⊗ | LIME | ⊗ |
| ENAMEL & CHEMICALS | □ | REFRACTORIES | ⊕ |
| GLASS | ● | TERRA COTTA | * |
| HEAVY CLAY PRODUCTS | ▲ | WHITE WARE | △ |

MINING AND QUARRYING INDUSTRIES OF PENNSYLVANIA



Federal Specifications

*Derived from Federal Standard Stock Catalog, Section IV, Part 1,
and Indices of Army and Navy Specifications*



R-24728 — Amendment No. 1—Armor Plate, Installation of, General Specification for

17T5 and
SGS(65)-42a — Bureau of Ships (letter)

AN-C-70 — Covers; Light-Transmitting (for Aeronautical Lights, Army-Navy Aeronautical Specification)

17D3b — Door-Glasses, Dome, Searchlight

75-53-B — Amendment No. 1—Filters; Photographic

AN5727 — Glass; Aircraft Instrument Cover, Army-Navy Aeronautical Std.

12G4d — Glasses, Airport and Light, Circular

() — Glass, Classification of

98-12017-A — Superseded by AN-C-70 — Glass, Colored & Clear (For Aircraft)

DD-G-426 — Glasses, Cover; (For) Microscopy

32G2c — Glass, Fibrous, Insulating

DD-G-451 — Glass; Flat for Glazing Purposes (Plate Glass, Window Glass, etc.)

DD-G-476 — Glass; Flat, Glazing (For) Transmitting Not less than 25% of Ultra-Violet Radiation at Wave Length 302 Millimicrons

13G3c — Glasses, Gage, Flat, Plain & Reflex, Over 125 Pounds Pressure

DD-G-491 — Glasses, Gage, Flat (Plain & Reflex), (For Pressures 125 Pounds and Over)

DD-G-496 — Glasses, Gage; Reflex & Round, Tank (For Pressures Under 125 Pounds)

13G1(INT) — Glasses, Gage, Round (For Pressures up to 200 Pounds)

- 13G2(INT) — Glasses, Gage, Round and Flat, Reflex—
Under 125 Pounds Pressure
- 50-11-23A — Glass, Ground
- 12G6(INT) — Glasses, Heat-Treated, Airport & Light,
Circular
- 12G8 — Glasses, Heat-Treated, Disk Type (Clear
View Screens)
- 59G3 — Glass, Heat-Treated, Glazing, Rectangular
(For Bridge Windows)
- 150RVO10341 — Glass and Glazing—Section
- 60G1a — Glasses, Port-Light, Evaporator
- 40751 — Kit; Rain Repeller, Type AA-1 (For Air-
craft Windows)
- M-578 — Navy Aeronautical Spec. for Engine Test
Cell Control Rooms, Carburetor Air
Intake Systems, Control Systems, etc.
- 40435 — Transparent Areas, Aircraft, Equipment
for Maintaining Vision
- MD-1644-D — Standard Specification for Marking Ship-
ments Used in lieu of U. S. Army Spec.
No. 100-2D dated 2-4-33
- D.T.D. 406A — De-Icing Fluid — Material Specification —
British
- — Army Air Force — Wright Field — XB-35
Airplane Bombsight Window Test Reports
—PPG Report 1268, FP-213 (drawing)—
(Specification 40118A) (Northrop Aircraft)
- 51-70-4A — Films, Reflection—Reducing, for glass opti-
cal elements
- 51-70-4 — Films, Reflection—Reducing, for glass opti-
cal elements
- D.T.D. 182A — 7 per cent Magnesium Aluminum Alloy
Sheets and Strips (Annealed) — Material
Specification—British
- D.T.D. 335A — Synthetic Resin Cement (Non-gap Filling)
Material Specification—British
- D.T.D. 400 — Petrol Resisting Paint—Material Specifi-
cation—British
- D.T.D. 484 — Synthetic Resin Cement (Cap Filling) —
British
- M-494a — Glass; Laminated Bullet-Resistant — Flat.
Navy Aeronautics.

A.S.A. SAFETY CODE FOR SAFETY GLASS

- Z26.1-1938 — A.S.A.—American Standard Safety Code for
Safety Glass

BOMBSIGHTS

- C-24711 — Bombsight Installation, Specification For
(Model M-Series)
- C-24711-A — Amendment No. 1 on above Specification
- R-24779 — Installation, Bombsight Accessory Equip-
ment (Bombardier's Compartment)
- R-24779-A — Superseding No. R-24779

BULLET-RESISTING

- 12031 — Glass: Bullet-Resistant
- 12031 — Amendment No. 1
- TT-P-781A — Type 1—Bullet-Resisting Glass
- M-194 — Navy Aeronautical Spec., Glass: Laminated,
Plane, Bullet-Resisting
- D.T.D. 402 — Material Specification, Bullet Proof Safety
Glass for Windscreen Panels
- D.T.D. 402A — Superseding D.T.D. 402
- M-194A — Glass; Laminated Bullet-Resistant—Flat,
Navy Dept., Bureau of Aeron.

GOGGLES

- 37G5(INT) — Bureau of Ships Ad Interim Specification—
Goggles, Rubber Frame
- 49G4 — Superseding 37G12, Navy Dept. Spec.—
Goggles, Aviators'
- GGG-G-511 — Superseding GGG-G-511—Federal Spec. for
Goggles; Protective (Glare and Welders')
- 37G7C — Navy Dept. Spec.—Goggles, Spectacle-Type,
for Protection against Flying Particles
and Chips

GUN SIGHT GLASS

- 93-24791 — Amendment No. 1—Reflector; Gun Sight
Glass
- 93-24794 — Superseding No. 24794
- 93-24794 — Amendment No. 2—Reflector; Gun Sight
Glass
- 24889 — Sight; Gun, Type N-8A
- 93-24659-A — Amendment No. 2—Sight, Fixed Gun, Type
N-3A
- 24704-A — Superseding Spec. No. 24704—Sight; Gun,
Type N-6A
- 93-24659-A — Superseding Spec. No. 93-24659

LAMINATED GLASS

- ACS:JC:60-16 — Supplement to Tentative Inspection Stand-
ards for Curved Laminated Glass
- AN-DD-G-551 — Amendment No. 1—Army-Navy Aeronau-
tical Spec. Glass; Laminated
- O.S.-1252 — Ordnance Specifications — Glass-Plastic
Laminated (Numerous Revisions)
- O.S.-1112 — Ordnance Specifications—Glass, Laminated
- CPD Insp.
Memo # 54 — Testing Curved Laminated Glass;
Distortion
- 81-11-C — Curved Laminated Glass Spec. — Instruc-
tions to Air corps Inspectors
- Specification for Bomber's Windows
- 12G5G — Superseding 12G5d — Navy Dept. Spec. —
Glass, Laminated
- 81-11-B — Superseding No. 81-11-A—U. S. Army Spec.

(Obsolete—See AN-DDG-551) —Glass, Laminated Non-Scatterable (For Aircraft Use)

LENS

- 197-51-130A — Superseding No. 197-51-130—Lens, Cylindrical, Laminated, 3-Ply
- 75-146-A — Amendment No. 4—Lens; Photographic, Tactical Mapping
- 75-283 — Superseding No. 31281—Lens; Photographic, Aerial Reconnaissance and Spotting
- 17L5 (INT) — Bureau of Ships Ad Interim Spec.—Lenses & Globes, Electric Light
- 191-51-130 — Chem. Warfare Service Spec.—Lens, Cylindrical, Laminated, 3-Ply
- 17L5d — Navy Dept. Spec.—Lenses & Globes, Electric Light
- 97-101-19E — Superseding No. 97-101-19D, U. S. Army Spec.—Lens, Laminated—3-Ply

MIRRORS, REFLECTORS, SEARCHLIGHTS (See Gunsight)

- M-580a — Navy Dept. Bureau of Aeronautics—Spec. for Emergency Signalling Mirror, Superseding M-580
- 26M1 (INT) — Mirrors (Shipboard Use)—Bureau of Ships Spec.
- 17R8 (INT) — Reflectors, Searchlights, Parabolic—Bureau of Ships Spec.
- 17M3d — Superseding 17M3c — Navy Dept. Spec.—Mirrors (Reflectors), Searchlight, Glass, Plate, Parabolic

OPTICAL GLASS

- O.S. 1076 — Ordnance Spec.—Plate Glass for Optical Instruments
- Sk. 99876 — Optical Instruments—Reflector Plate (Illuminated Sight Mark)—Requisition Sheet

12027-A — Superseding No. 12027—Air Corps Spec.—Glass, Optical (For Aerial Camera Lenses)

PHOTOGRAPHIC, SELECTED PLATE GLASS

- 75-357 — Amendment No. 2—Glass, Selected Plate (Photographic)
- 31334 — Army Air Forces Spec.—Glass, Selected Plate (Photographic)

REFLECTION-REDUCING FILMS

- O.S. 1357 — Navy Dept. Spec. for—Reflection-Reducing Films Produced by the Evaporation Process

SIGHT-ILLUMINATED SIGHT MARK

- O.S. 2366 — Spec. for Procurement of Illuminated Sight Mark 1X
- O.S. 2349 — Spec. for Procurement of Illuminated Sight, AE, Mark 8

FILTERS

- 75-53-A — Filters: Photographic (For Aircraft Cameras) Superseding 75-53.
- 75-53-B — Amendment No. 2 on above specification
- 75-367 — Amendment No. 2—Filters, Photographic (For Ground Cameras)
- O.S. 1386 — Supersedes O.S. 1155 — Specification for Polarizing Filters
- AN-C-56 — Amendment No. 2—Army-Navy Aeronautical Spec.—Colors; Aeronautical Lights and Lighting Equipment.
- 31302 — Amendment No. 2—Filters: Photographic, Vignetting—Correction
- AN-C-70 — Covers, lighting transmitting

Comparable Trade Names

OF

SIMILAR PATTERNS OF THE FLAT GLASS INDUSTRY

Showing Possibility of Tempering

PLATE GLASS PRODUCTS

Can be Tempered			
Yes	No		
		Pittsburgh Plate Glass Company	Libbey-Owens-Ford Glass Company
x		Vista Plate $\frac{1}{8}$	$\frac{1}{8}$ Plate Glass
x		Regular Plate Glass $\frac{13}{64}$ and $\frac{1}{4}$	Regular Plate Glass $\frac{13}{64}$ and $\frac{1}{4}$
x		Heavy Plate Glass $\frac{3}{8}$ to $1\frac{1}{4}$	Heavy Plate Glass $\frac{3}{8}$ to $1\frac{1}{4}$
x		Rough Plate $\frac{21}{64}$ to $1\frac{3}{8}$	Rough Plate $\frac{21}{64}$ to $1\frac{3}{8}$
x		Crystalex Plate Glass	Color Clear Plate Glass
x		—	Light Blue Plate Glass
x		Blue Plate Glass	Medium Blue Plate Glass
x		—	Dark Blue Plate Glass
x		Flesh Tinted Plate Glass	Peach Plate Glass
x		X-Ray Lead Glass	—
x		Solex Heat Absorbing Glass	L.O.F. Heat Absorbing Glass
x		Tapestry $\frac{3}{16}$, $\frac{1}{4}$	—

	Can be Tempered		Pittsburgh Plate Glass Company	Libbey-Owens-Ford Glass Company
	Yes	No		

LIGHTING GLASSES

x			Rough Water White $\frac{10}{64}, \frac{12}{64}, \frac{21}{64}$	—
x			Reeded Water White $\frac{10}{64}$	—
x			Reeded Opal $\frac{10}{64}$	—
x			Rough Opal $\frac{9}{64}$	—
x			Rough Flesh Tinted $\frac{9}{64}, \frac{19}{64}$	—

STRUCTURAL GLASS

x			Carrara	Vitrolite
x			Black	—
x			White	—
x			Ivory	—
x			Gray	—
x			Beige	Sun Tan
x			—	Princess Blue
x			Rembrandt Blue	—
x			—	Cadet Blue
x			—	Yellow
x			—	Red
x			Wine	Mahogany
x			—	Tropic Green
x			Forest Green	—
x			—	Jade
x			Tranquil Green	—
x			Orange	—
x			—	Orchid Agate
x			—	Royal Blue Agate
x			—	Walnut Agate
x			—	Emerald Agate
x			—	Jade Agate

ENAMELED GLASSES

x			Enameled Glass $\frac{7}{64}$ to $1\frac{1}{4}$	Vitrolux
x			Nucite $\frac{1}{4}$	—

WINDOW (SHEET) GLASS

Pittsburgh Plate Glass Company	American Window Glass Company	Fourco Glass Company	Libbey-Owens-Ford Glass Company
Pennvernon	Lustra Glass	Clearlight	L-O-F
—	Lantern Slide	—	—
Photo Glass	Photo Glass	Photo Glass	Photo Glass
Picture Glass	Picture Glass	Picture Glass	Picture Glass
Single Strength	Single Strength	Single Strength	Single Strength
Double Strength	Double Strength	Double Strength	Double Strength
Heavy Sheet $\frac{3}{16}, \frac{7}{32}$	Heavy Sheet $\frac{3}{16}, \frac{7}{32}$	Heavy Sheet $\frac{3}{16}, \frac{7}{32}$	Heavy Sheet $\frac{3}{16}, \frac{7}{32}$
—	—	Heavy Sheet $\frac{1}{4}$	—
—	Lustra Blue	—	—

ROLLED GLASSES

WIRE GLASS CANNOT BE TEMPERED

Can be Tempered Yes No	Pittsburgh Plate Glass Company	Mississippi Glass Company	Blue Ridge Glass Corporation	Pennsylvania Wire Glass Company	Sergeant Wire Glass Corporation	Southwestern Sheet Glass Company
x	—	Artex $\frac{1}{8}$, $\frac{7}{32}$	Muralex $\frac{1}{8}$, $\frac{7}{32}$	—	—	—
x	—	Artex Pol. $\frac{7}{32}$	Muralex Pol. $\frac{7}{32}$	—	—	—
x	—	Aurora $\frac{1}{8}$, $\frac{7}{32}$	—	—	—	—
x	—	Aurora Pol. $\frac{7}{32}$	—	—	—	—
x	—	Bandlite $\frac{1}{8}$, $\frac{7}{32}$	Flutex $\frac{1}{8}$, $\frac{7}{32}$	—	—	—
x	—	Bandlite Pol. $\frac{7}{32}$	Flutex Pol. $\frac{7}{32}$	—	—	—
x	—	Bevelite $\frac{1}{8}$, $\frac{7}{32}$	Louvrex $\frac{1}{8}$, $\frac{7}{32}$	—	—	—
x	—	Bevelite Pol. $\frac{7}{32}$	Louvrex Pol. $\frac{7}{32}$	—	—	—
x	—	—	—	—	Colonial $\frac{1}{8}$, $\frac{7}{32}$	—
x	—	Coolite Ham. $\frac{1}{8}$, $\frac{1}{4}$	Aklo Ham. $\frac{1}{8}$, $\frac{1}{4}$	Actinic Ham. $\frac{1}{8}$, $\frac{1}{4}$	—	Thermolite $\frac{1}{8}$, $\frac{7}{32}$
	x	Coolite Ham. Wire $\frac{1}{4}$	Aklo Ham. Wire $\frac{1}{4}$	Actinic Ham. Wire $\frac{1}{4}$	—	Thermolite Wire $\frac{1}{4}$
x	—	Coolite Rib $\frac{1}{8}$, $\frac{1}{4}$	Aklo Rib $\frac{1}{8}$, $\frac{1}{4}$	Actinic Rib $\frac{1}{8}$, $\frac{1}{4}$	—	—
	x	Coolite Rib Wire $\frac{1}{4}$	Aklo Rib Wire $\frac{1}{4}$	Actinic Rib Wire $\frac{1}{4}$	—	—
x	Solex Rough $\frac{1}{8}$, $\frac{1}{4}$, $\frac{3}{8}$	—	—	Actinic Rough $\frac{1}{8}$, $\frac{1}{4}$	—	—
	x	—	—	Actinic Rough Wire $\frac{1}{4}$	—	—
	x	Coolite Pol. Wire $\frac{1}{4}$	Aklo Pol. Wire $\frac{1}{4}$	—	—	—
x	—	Corrugated	—	Corrugated	Corrugated	—
	x	Corrugated Wire	—	Corrugated Wire	Corrugated Wire	—
x	—	Corrugated Coolite	—	—	—	—
	x	Corrugated Coolite Wire	—	Corrugated Actinic Wire	—	—
x	—	Dewlite $\frac{1}{8}$, $\frac{7}{32}$	Diffusex $\frac{1}{8}$, $\frac{7}{32}$	—	—	—
x	—	Dewlite Pol. $\frac{7}{32}$	Diffusex Pol. $\frac{7}{32}$	—	—	—
x	—	—	Doublex $\frac{7}{32}$	—	—	—
x	—	Factrolite $\frac{1}{8}$, $\frac{7}{32}$	Industrex $\frac{1}{8}$, $\frac{7}{32}$	—	—	—
	x	Factrolite Wire $\frac{1}{4}$	Industrex Wire $\frac{1}{4}$	—	—	—
x	—	Florentine $\frac{1}{8}$	Florex $\frac{1}{8}$	Florentine $\frac{1}{8}$	Florentine $\frac{1}{8}$, $\frac{7}{32}$	Florentine $\frac{1}{8}$, $\frac{7}{32}$
	x	—	—	—	Florentine Wire $\frac{1}{8}$	—

ROLLED GLASSES

Can be Tempered		Pittsburgh Plate Glass Company	Mississippi Glass Company	Blue Ridge Glass Corporation	Pennsylvania Wire Glass Company	Sergeant Wire Glass Corporation	Southwestern Sheet Glass Company
Yes	No						
x		—	—	—	—	Gothic $\frac{7}{32}$	—
	x	—	—	—	—	Gothic Wire $\frac{1}{4}$	—
x		—	Hammered $\frac{1}{8}, \frac{7}{32}, \frac{3}{8}, \frac{1}{2}$	Hammered $\frac{1}{8}, \frac{7}{32}, \frac{3}{8}, \frac{1}{2}$	Hammered $\frac{1}{8}, \frac{7}{32}$	Hammered $\frac{1}{8}, \frac{7}{32}, \frac{3}{8}$	Dewdrop $\frac{1}{8}, \frac{7}{32}, \frac{3}{8}, \frac{1}{2}$
	x	—	Hammered Wire $\frac{1}{4}, \frac{3}{8}, \frac{7}{16}, \frac{1}{2}, \frac{5}{8}, \frac{3}{4}, \frac{7}{8}$	Hammered Wire $\frac{1}{4}, \frac{3}{8}, \frac{1}{2}$	Hammered Wire $\frac{1}{4}, \frac{3}{8}$	Hammered Wire $\frac{1}{4}, \frac{3}{8}$	Dewdrop Wire $\frac{1}{4}, \frac{3}{8}, \frac{1}{2}$
x		—	Hylite $\frac{1}{8}, \frac{7}{32}$	Luminex $\frac{1}{8}, \frac{7}{32}$	—	—	—
	x	—	Hylite Wire $\frac{1}{4}$	Luminex Wire $\frac{1}{4}$	—	—	—
x		—	—	Linex $\frac{1}{8}, \frac{7}{32}$	—	—	—
x		—	—	Linex Pol. $\frac{7}{32}$	—	—	—
x		—	Luxlite $\frac{1}{8}, \frac{7}{32}$	Pointex $\frac{1}{8}$ thin	—	—	—
x		—	xMagnalite A and B $\frac{7}{32}$	—	—	—	—
	x	—	xMagnalite Wire A and B $\frac{1}{4}$	—	—	—	—
x		—	—	Mazex $\frac{1}{8}, \frac{7}{32}$	—	Maze $\frac{1}{8}, \frac{7}{32}$	Meteor $\frac{1}{8}, \frac{7}{32}$
	x	—	—	Mazex Wire $\frac{1}{4}$	—	Maze Wire $\frac{1}{4}$	—
	x	—	Misco Ham. $\frac{1}{4}$	—	—	—	—
	x	—	Misco Sycnite $\frac{1}{4}$	—	—	—	—
	x	—	Misco Pol. $\frac{1}{4}$	Nuweld Pol. $\frac{1}{4}$	—	—	—
x		—	Pentecor $\frac{1}{8}, \frac{7}{32}$	Skytex $\frac{1}{8}, \frac{7}{32}$	—	Riblite $\frac{1}{8}, \frac{7}{32}$	—
	x	—	Pentecor Wire $\frac{1}{4}$	Skytex Wire $\frac{1}{4}$	—	Riblite Wire $\frac{1}{4}$	—
x		—	Pluralite $\frac{1}{8}, \frac{7}{32}$	—	—	—	—
	x	—	Polished Wire $\frac{1}{4}, \frac{3}{8}, \frac{1}{2}, \frac{5}{8}, \frac{3}{4}$	Pol. Wire $\frac{1}{4}$	—	—	—
x		—	Prestlite $\frac{1}{8}, \frac{7}{32}$	Reglex $\frac{1}{8}, \frac{7}{32}$	—	Pyramid $\frac{7}{32}$	Pyramid $\frac{1}{8}, \frac{7}{32}$
x		—	Prestlite Pol. $\frac{7}{32}$	Reglex Pol. $\frac{7}{32}$	—	—	Pyramid Pol. $\frac{7}{32}$
?	?	—	—	—	—	xxPressed Lens $\frac{1}{4}$	—
	x	—	—	—	—	xxPressed Lens Wire $\frac{1}{4}$	—
?	?	—	—	—	—	xxLens Rib $\frac{1}{4}$	—
	x	—	—	—	—	xxLens Rib Wire $\frac{1}{4}$	—

ROLLED GLASSES

Can be Tempered		Pittsburgh Plate Glass Company	Mississippi Glass Company	Blue Ridge Glass Corporation	Pennsylvania Wire Glass Company	Sergeant Wire Glass Corporation	Southwestern Sheet Glass Company
Yes	No						
?	?	—	—	—	—	xxLenslite 1/4	—
	x	—	—	—	—	xxLenslite Wire 1/4	—
?	?	—	—	—	—	—	Prism 1/4
	x	—	—	—	—	—	Prism Wire 1/4
x		—	Ribbed 1/8, 7/32 3/8, 1/2	Ribbed 1/8, 7/32 3/8, 1/2	Ribbed 1/8, 7/32 3/8, 1/2	Ribbed 1/8, 7/32 3/8	Ribbed 1/8, 7/32 3/8, 1/2
	x	—	Ribbed Wire 1/4, 3/8, 7/16, 1/2 3/8, 3/4, 7/8	Ribbed Wire 1/4, 3/8 1/2	Ribbed Wire 1/4, 3/8	Ribbed Wire 1/4, 3/8 1/2	Ribbed Wire 1/4, 3/8 1/2
x		—	xxxSmooth Rough 1/8, 7/32	Velvex 1/8, 7/32	Rough 1/8, 7/32 3/8	—	Plainlite 1/8, 7/32
	x	—	xxxSmooth Rough Wire 1/4	—	Rough Wire 1/4, 3/8	—	—
x		—	—	—	—	Silverite 1/8, 7/32	—
	x	—	—	—	—	Silverite Wire 1/4	—
?	?	—	—	Stylex 1/8, 7/32	—	—	—
?	?	—	—	Stylex Pol. 7/32	—	—	—
x		—	Syenite 1/8, 7/32	Peblex 1/8, 7/32	—	—	Crepe 1/8, 7/32
x		—	Syenite Pol. 7/32	Peblex Pol. 7/32	—	—	Crepe Pol. 7/32
	x	—	—	—	—	—	Crepe Wire 1/4
	x	—	—	—	—	—	Crepe Pol. Wire 1/4

Pressed Prism Plate Glass Company makes Polished Figured Glass in Patterns 0-1 to 0-7, inclusive. Can be Tempered.

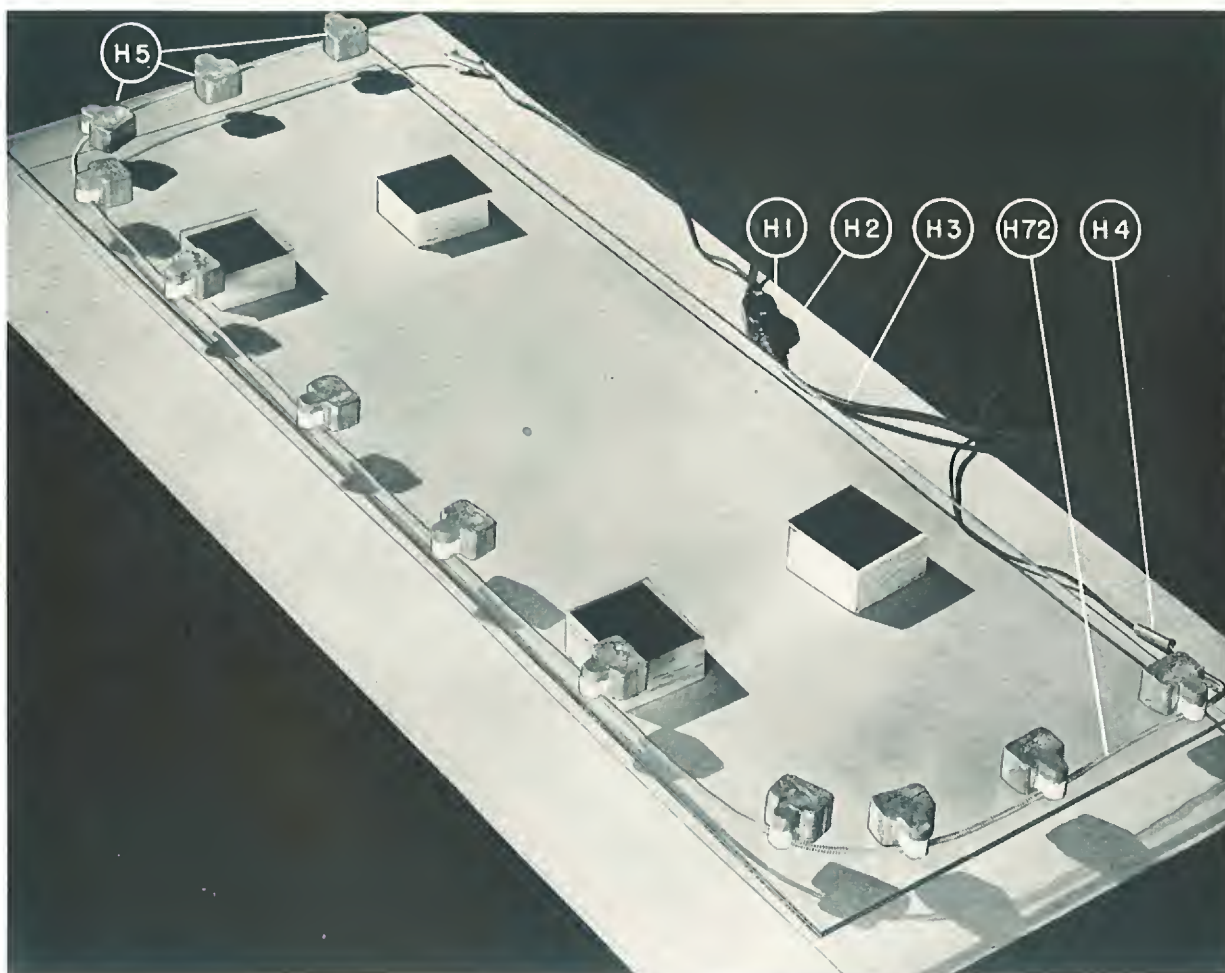
Ham. means Hammered; Pol. means Polished.

xMagnalite and Magnalite Wire are made exclusively for J. Merrill Richards.

xxPressed Lens, etc. (plain and wire) are made exclusively for Manufacturers Glass Co.

xxxFor sale on Pacific Coast only.

Glass Cutting



Model "H" nichrome hot wire cutting set used in cutting laminated safety glass.

H₁—6 ft. extension cord to electric circuit.

H₂—Electric on and off switch.

H₃—12 ft. single wire leads to heater element.

H₄—Standard sleeve connector to join H₃ and H₇₂.

H₅—Insulated lead blocks for locating H₇₂ adjacent to cut.

H₇₂—72" spiral nichrome heating element.

GLASS CUTTING is an art. It requires observation of detail, the acquisition of skill and delicacy of touch which only practice can develop. The pressure exerted should be just sufficient to sing, and make a mark barely visible on the glass. The pressure used varies directly with the thickness of the glass, and the depth of penetration of the cut varies accordingly.

The cutter should be held so that the plane of the wheel edge is normal to the glass, and does not make an angle with the intended line of the

cut. If the plane of the wheel makes an angle with the cut, the result will be a scratch or at best a rough ragged cut which will not snap true. The cut is actually the trace of the plane of the wheel on the glass.

The cutter wheel should be kept well lubricated with kerosene or light lubricating oil, and a cloth or finger cot soaked in the same lubricant should be drawn along the proposed path of the cut before tracing the cut with the cutter.

A cut once put on the glass should never be

retraced, since the second tracing will always roughen the edges and may cause the cut to jump.

The edge of the cutter wheel must be true and should not have any nicks or gaps. It should run free but not wobbly on its axle. If there are nicks in the edge of the wheel or it binds on its axle, the trace of the cut is likely to skip, so that there are gaps along the cut which will snap erratically, resulting in loss of the glass. The edge of the cutter wheel should always be kept satisfactorily sharp.

For all practical purposes outside of the factory, wheel-type glass cutters should be used. Diamond cutting points are seldom used outside of the factory, and then only by men experienced in their use. They are used on heavy or rough surfaced glass.

Glass should always be cut to save the largest rectangular or square sizes, not necessarily the greatest over-all area.

Cutting should always be done in a normally warm room at about 60° to 70°F., and every effort should be made to avoid tracing a cut on glass at temperatures materially above 110°F. The surface of the glass should be wiped clean and free from water before tracing a cut. Remember to lubricate the path of the cut.

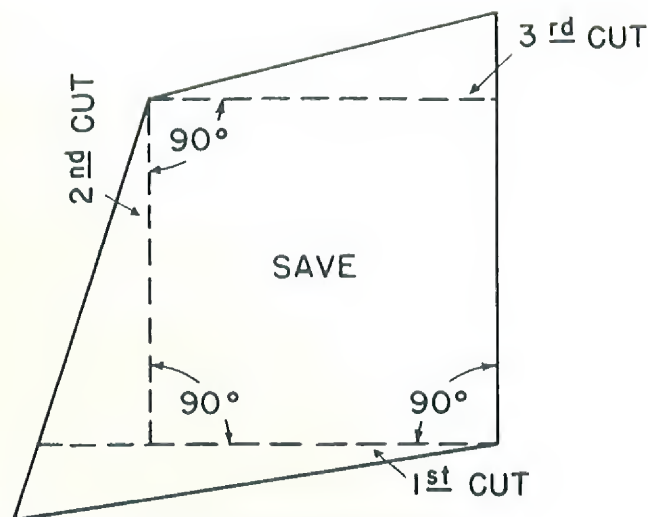
Re-entrant sharp corners cannot be cut. There must always be a curved fillet (see sketch) in the corner, joining the two main lines of the cut. This fillet may be ground out subsequently, if necessary. Cuts of this type should be opened first at the fillet. Otherwise the cut may not follow through.

A cut should always extend continuously from one edge of the glass to another, and the cut should be opened and run before another cut is put on the glass. Almost never should one cut intersect another. Scribe, and snap each cut, successively.

To make a satisfactory cut on glass, the cutter should be held between the index finger and second finger, supported by the thumb, so that the tips of the fingers and thumb contact the stem of the cutter. When held in this manner, it is simple to scribe a straight line cut. The flat face of the stem should be drawn along the edge of a smooth wood straightedge, preferably about 1/4 inch thick and from 2 to 3 inches wide. However, successfully scribing free-hand curve cuts, even when templates are used, is difficult skilled work, and requires considerable practice. The plane of the cutting wheel must be held tangent to the desired curve at all times. Circles should always be scribed by a cutter rigidly fastened to a horizontal scribing arm which may turn about a fixed vertical axis.

When scribing a cut, the glass should always be firmly supported under the cutter, so that there may be no tendency for the glass to bend and run a vent ahead of the cutter. A cut, vent or other crack in glass will progress at the rate of 5,280 feet per second.

There are several ways to open or run a cut, depending somewhat upon the size of the glass. A large glass may be laid on a table top with the scribed cut just over the edge of the table. Pressure should be exerted gently upon the overhanging edge, moving the point of pressure forward as the cut opens. If the overhang is only an inch or so wide, square-jawed glass cutter's pliers should be used to bend the glass. The cut face of the glass should always be up, so that



Save Largest Possible Rectangle.

when the overhang is bent downward, the greatest tension will come at the line of the cut.

Snapping or opening the cut may be effected by placing the cutting straightedge under the glass along the line of the cut (Fig. 4)* and then exerting pressure on either side of the cut. A strip of thin cardboard with a straight edge will serve the same purpose. The weight or thickness of the cardboard strip may be increased for larger sizes, but it should be kept as thin as possible. A reasonably heavy stretched cord or line may be used in the same way, with the cord as *nearly under the cut as possible*. Small pieces of glass may be held in the hands and snapped as shown in Figure 3. To avoid flare or razor edges on a glass, do not remove any strip whose width is less than twice the thickness of glass. A beginner should not try to cut off more than 2 inches at a time and should open the cut at the edge of plate by gently tapping the glass directly under the cut with the ball end of the cutter stem or the back of the cutter's pliers before attempting to run the cut.

In cutting circles or complex curves, the cut should be opened cautiously, and then relief cuts made at various points from the cut to the edge of the original plate and opened progressively, so that the curved piece may be freed without chipping (Fig. 5, 6, 7). Circular cutouts (Fig. 7) are difficult to make successfully.

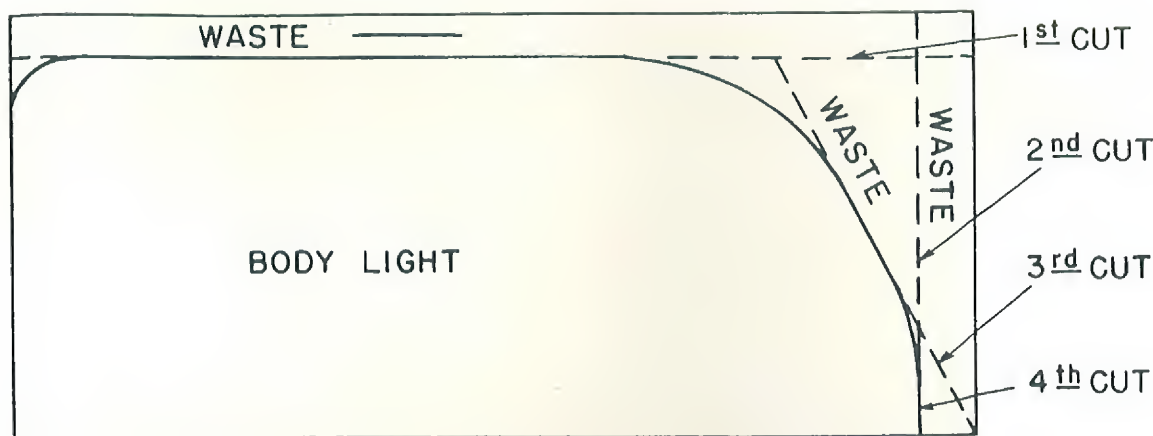
*See Figures 1 to 7, on I-1 - 6.

CUTTING HEAVY GLASS

The methods used for cutting heavy glass are quite similar to those just described.

However, there are some essential differences due chiefly to the extra thickness involved. Cutting requires slightly different procedure and more experience.

Either a diamond or a wheel is suitable for making the cut. Most experienced cutters prefer a wheel, but the cut must be heavy in proportion to the thickness. For example, the pressure in making a cut on 1/2 inch glass should be double that for 1/4 inch, and for 3/4 inch, still heavier in proportion, but great care must be taken to prevent the cut from flaking. Flaking sometimes occurs when the wheel is too sharp. To dull the wheel slightly, it should be rubbed over a fine file. A great many failures which occur in attempting to cut heavy glass are due to lack of pressure in making the cut; another important point is to see that the



A Design for Cutting.

cut is thoroughly saturated with oil to prevent it from healing before the actual fracture can be made. Kerosene is most satisfactory for this purpose.

It is often characteristic of heavy glass that the edges of plates are somewhat harder than the centers. Bearing this in mind, a good cutter, if he has any choice, will always make the cut crosswise of the plate. Good judgment should guide the cutter as to how and where he makes the cut. To illustrate: suppose four 5 inch strips are required, the first cut should be made 20 inches from the edge. This piece should then be snapped in the center and the resulting 10 inch pieces cut through the center. This is the most practical way to cut strips. In order to cut off the 20 inch piece, a $\frac{3}{8}$ or $\frac{1}{2}$ inch straightedge should be used under the cut for making the snap. The smaller section of the plate is held down firmly, and the larger section snapped from the smaller section. The weight of the larger section is often sufficient to make the snap. If not, pressure must be exerted.

Cutting tables, designed for heavy glass, are perfectly level and solid and have a strip with a slight projection to form a slot fastened along the back edge for the purpose of holding down the edge of the plate. This strip is arranged to take the heaviest glass; lighter glass is held tightly against the table laying one or two straightedges on top of the glass and under the projection.

All cuts up to about 10 inches wide, when taken from the edges of a large plate are risky; and skill plus experience plays its part. Usual practice is to get the cut properly made and then tap one end to get the fracture started, using glass nippers to extend it down the length. In some cases it is helpful to have one or two men along the edge to assist in pulling it off with hand pressure.

A general rule might be that widths under 12 inches, when taken from the edge of a full sheet, should be tapped and over 12 inches, snapped with the straight edge under the cut as explained above, but here again, conditions and judgment play an important part.

It will be helpful to test the wheel or diamond on a piece of cullet before making the actual cut to be sure that no flaking occurs when heavy pressure is used.

BENT GLASS

All bent glass must be cut on the concave or inside surface of glass. Never remove more than a 2 inch strip at a time when cutting bent glass.

LAMINATED SAFETY GLASS

Laminated glass *must* be at a temperature of 75°F. or above if satisfactory cutting is to be achieved. Do not attempt to trace a cut on glass at temperatures materially above 110°F.

The same procedure as for plate glass or window glass is followed in cutting laminated safety glass with several additional conditions to be met.

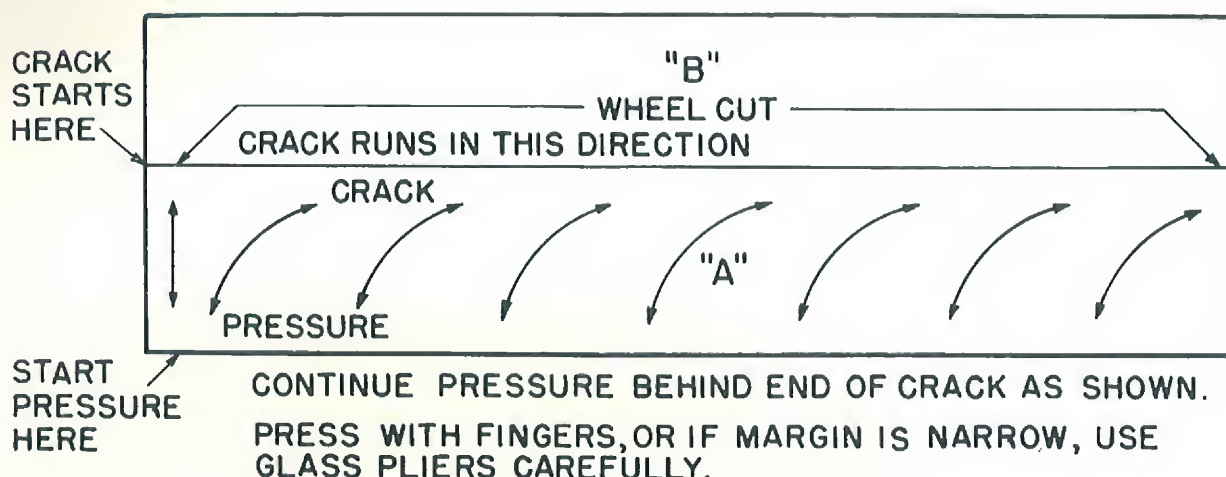
A cut is placed on one face of the glass and opened carefully, preferably using the cardboard or stretched cord method and the least possible bending. The glass is then turned over (face for face) and a cut placed on the second face *directly over the first cut*. This is *very* important. This cut is run or opened as before, but the laminated glass is not yet completely cut.

If the hot wire cutting device is available, its use at this stage should practically eliminate breakage during the cutting process, and greatly reduce breakage during the edging process and immediately after installation. Perhaps the chief cause of breakage is the chipping or venting of the inside glass edges while attempting to remove the waste part of the glass.

In using the hot wire, the glass should never be placed on the wire. The wire should always be placed on the top side of the glass blocked up from the asbestos-covered table about two inches with felt-covered blocks. This method will prevent the heat from spreading into the good side of the glass and avoids breaking the good glass.

The hot wire should be placed on the waste side of the glass $\frac{1}{16}$ to $\frac{3}{16}$ inch from the cut. The hot wire will require only a few minutes to generate enough heat to soften the plastic and allow the operator to remove the waste glass with ease and without the aid of a safety razor blade. This should be done by pulling the glass carefully apart, as nearly horizontally as possible. This method will eliminate forcing, chipping of the glass edges, and pulling of the plastic, and will prevent small runs and vents, not readily visible at the time of installation, which might later develop into cracks.

If the hot wire device is not available, the glass is clamped (or held by a second person) securely against a table top, with the waste piece of glass overhanging the edge of the table. Using a pair of glass cutter's pliers with one hand, the operator grips the glass and pulls as nearly horizontally as possible, so that the cut is opened just wide enough to permit the introduction of a safety razor blade. With the



Snapping or Opening the Cut.

other hand, the operator draws the safety razor blade along the cut, cutting *entirely* through the plastic as he does so. Stretching and cutting the plastic may be facilitated if the glass is immersed in water at a temperature of 160°F. to 170°F. for a short period not to exceed 60 seconds. It is important that *the whole sheet be immersed*. Then, *immediately* upon removing the glass from the bath, the plastic membrane is cut as just described.

Stand plate on open rack until it has cooled to near room temperature before edging. Do not attempt to force cooling with a fan or by standing the plate in a draft.

A box 8 inches deep, 24 inches wide and 48 inches long approximately half-filled with sawdust will speed up the drying of the glass removed from the hot water tank, and will also be helpful in cleaning and drying glass when the grinding and polishing operation has been completed. The glass can be laid in this box where the rubbing of the sawdust over the glass has a tendency to clean as well as dry the surface. The excess sawdust can be brushed off very easily with a small bench brush. Locate the sawdust box so that grit or abrasive will not be introduced.

CUTTING TROUBLES, CAUSES AND CURES

If any difficulty is experienced in making cuts, opening or running cuts or cutting plastic, the operator should go over the following very carefully.

1. POOR CUTS:

Skips or blank sections in the mark made by the cutting wheel.

- (a) Cause—Poor or dull cutting wheel. Wheels occasionally become flat on part of the edge.
Cure—Try a new wheel.
- (b) Cause—Uneven pressure on wheel in making cut.
Cure—Use even pressure, practice on scrap glass.
- (c) Cause—Frozen wheel—wheel not revolving as cut is made.
Cure—Free the wheel or try new stem and wheel.

Wheel usually can be freed with kerosene. Always dip wheel in kerosene or light oil before making a cut.

- (d) Cause—Too much pressure.
Cure—Press just hard enough to mark glass clearly.
- (e) Cause—Glass not lying entirely on level table.
Cure—See that there is no overhang.

2. RAGGED AND CHIPPED CUTS:

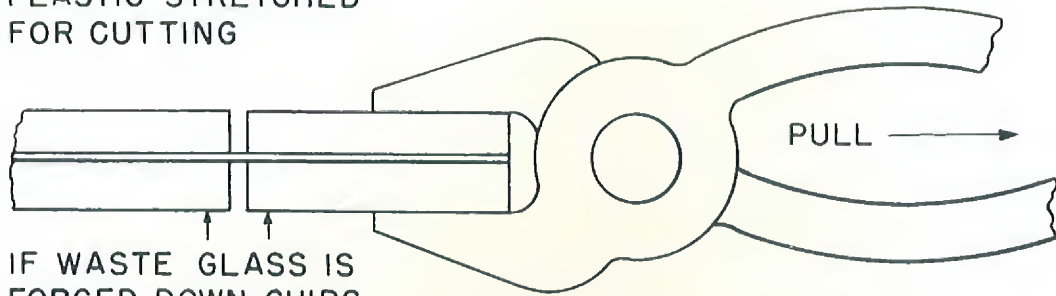
- (a) Cause—Too much pressure, poor wheel, or cutter not held properly.
Cure—Practice or try new wheel. (Too much pressure on a new wheel may be bad.)
- (b) Cause—Failure to use kerosene or other lubricant.
Cure—Always dip cutter in kerosene, or other light oil before making each cut. To avoid flaking, coat the surface of the plate, where the cut is to be made, with the lubricant. It is suggested that cutting wheels be kept immersed in a small, shallow can-lid partially filled with kerosene or other light oil, when not in use. This is also convenient for dipping cutter prior to making cuts on glass.

NOTE: A firm even pressure will make the best cut. A good cut is clean and even, with a shine when wiped dry. Flakes of glass, rough lines, chips, wide marks and continued chipping indicate the need of further practice on the part of the operator, or that the plate surface needs oil. Never attempt to cut through drops of water.

3. CRACKING OF GLASS AWAY FROM THE LINE OF CUT:

- (a) Cause—Poor cutting. See above causes.
Cure—New Wheel. More practice.
- (b) Cause—Failure to hold glass cutter square with rule, or pattern.
Cure—If cutter wheel drags sideways slightly, the cut will appear "snowy," somewhat the same as the application of too much pressure. Be sure to hold the glass cutter so that the side is flat against the rule or pattern. If the edge of the rule or pattern causes the

PLASTIC STRETCHED FOR CUTTING



IF WASTE GLASS IS
FORCED DOWN CHIPS
WILL RESULT HERE

The use of glass pliers.

cutter to drag, apply oil or grease to the edge. Never allow cutter to be out of line with the direction of the cut.

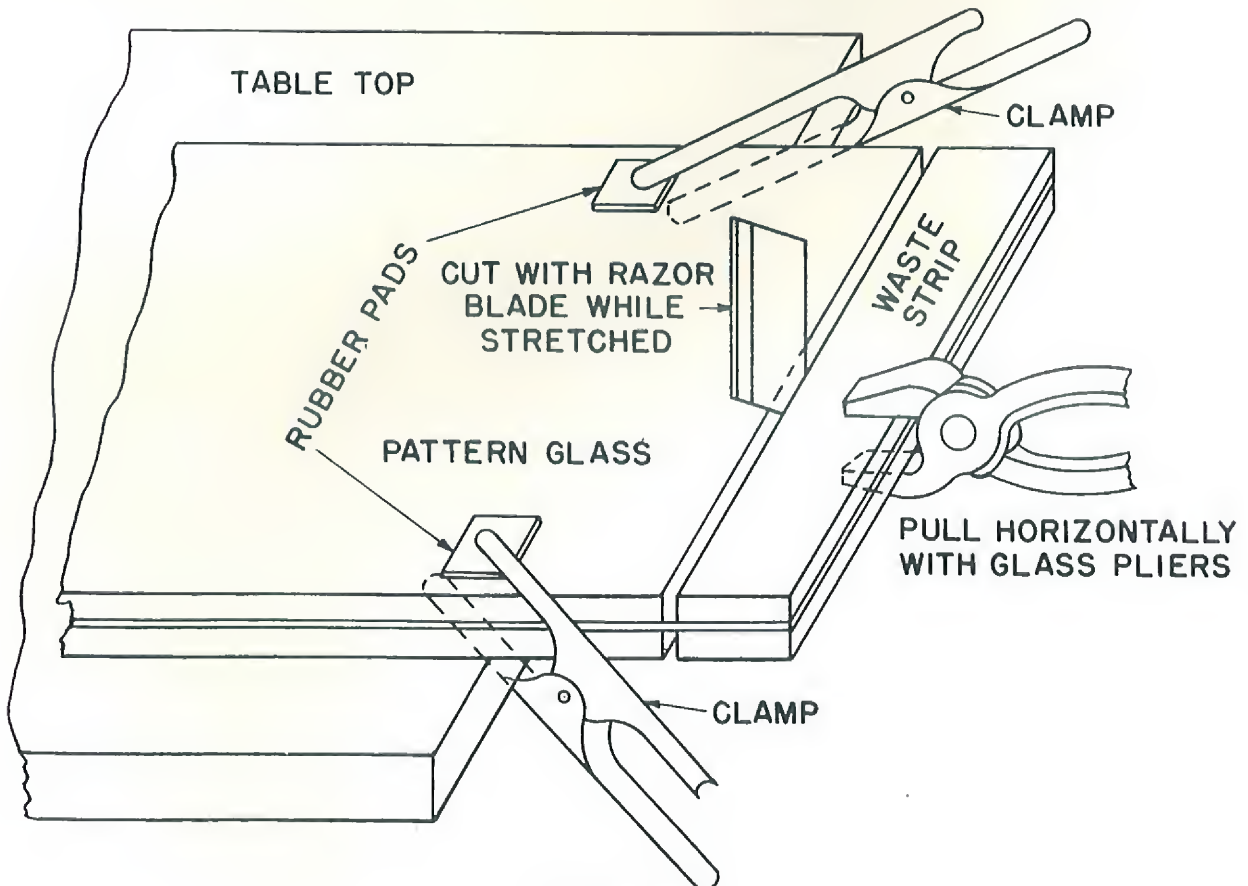
(c) Cause—Cold air drafts on the glass.

Cure—Be sure you are cutting in a normally warm room, 60 to 75°F. Glass must be at 75°F, or above when cutting. A cold piece of glass brought into a warm room has internal strains in it because the outside surface is warm and the inside is colder. Allow plate to warm up thoroughly before cutting.

(d) Cause—Failure to run the crack before the cut gets cold. A cut will heal in one or two minutes, appearing the same but losing its ability to guide the crack. Cure—Do not allow much time to elapse before running the crack. As each cut is made, it should be opened.

(e) Cause—Too much pressure in running crack.

Cure—Apply just enough pressure to crack and no more. Do not attempt to run the crack clear across the plate by one operation. Never apply pressure ahead of the crack.



Cutting the plastic.

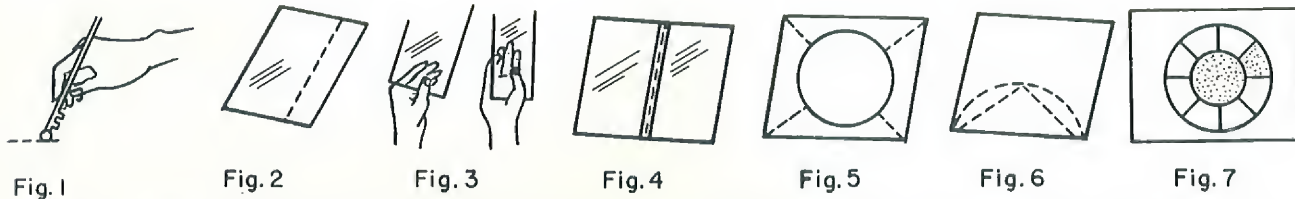


Fig. 1. Hold the cutter as shown here. Fig. 2. Trace the cut from edge to edge of the glass. Fig. 3. Snap the cut by exerting a slight bending and pulling effort, simultaneously. Fig. 4. Snap the cut by placing the glass on a straight-edge, with the cut at or very near the edge of the straight-edge. Exert downward pressure on *both* sides of cut. Fig. 5. To cut a circular piece of glass, scribe the circle cut and open it all around by tapping, and light pressure around the circle. Then cut from the circle to the corners of plate, and snap the corner cuts. The edge pieces will come away easily. Fig. 6. To make a curved cut-out, scribe the curved cut, and open carefully as in the case of the circle. Then

scribe angular cuts as indicated, snap, and remove the center section first and then the remaining sections. Fig. 7. To make a circular cut-out in a plate, great care must be used. The circle is scribed and the cut run. Then a secondary inner circle is scribed and run. Then radial cuts are made from the outer circle to the inner one, and the cuts opened. Using care, the center circle is now chipped out with the knot of the cutter, then one of the pie-shaped segments, and thereafter the remaining segments should come away without trouble. Do not expect to successfully make a circular cut-out, the first several times you try.

- (f) Cause—especially on *LAMINATED GLASS*—Carelessness on the part of the cutter in failing to make the second cut directly over the first.
Cure—Good lighting conditions, careful cutting and experience. The offset formed by uneven cuts subjects the glass to a severe strain when the cracking operation takes place.

4. DIFFICULTY IN STRETCHING PLASTIC:

- (a) Cause—Not enough heat.
Cure—Use the hot wire for a longer time.
(b) Cause—Failure to cut plastic quickly enough after heat application.
Cure—Cut plastic as soon as possible. It must be cut before the plate cools.
(c) Cause—Cut not open at some point; this is often the case when the waste strip is narrow.
Cure—Rerun the cut.

5. BUBBLING IN CENTER LAYER OF PLASTIC:

- (a) Cause—Heating too long with hot wire. The plastic bubbles when burned.
Cure—Shorten heating period or lengthen wire, if too hot. The wire when heated should be about a Cherry Red. If glowing brightly increase its length. Heating wire should always be on waste side of cut.

6. EXCESSIVE SEPARATION ALONG EDGE OF CUT:

- (a) Cause—Bending the waste strip down too far, thereby

stretching the plastic until it becomes thin.
Cure—Open cut just enough to insert razor blade.

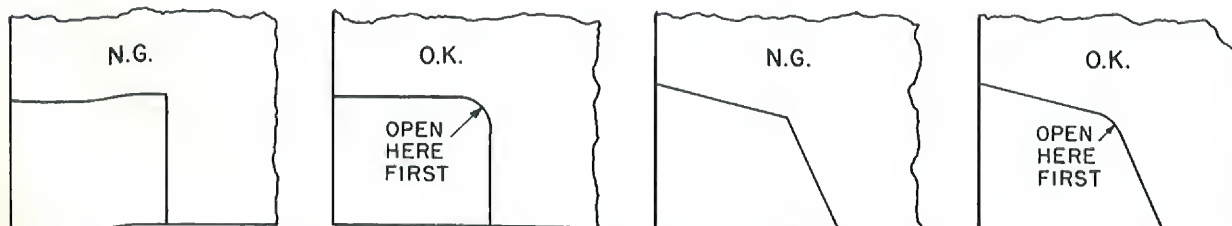
7. EXCESSIVE CHIPPING ALONG CUT:

- (a) Cause—Forcing the waste-edge downward.
Cure—Pull straight out with glass pliers.

8. DON'T'S:

- (a) Do not exert too much pressure in cracking and stretching plastic.
(b) Do not jar or bump a plate while hot.
(c) Do not make a fresh cut on a hot plate.
(d) Do not wet a hot plate.
(e) Do not apply hot wire to plate colder than room temperature.
(f) Do not apply heat too long.
(g) Do not place hot wire on pattern side of a cut.
(h) Do not stop cuts before they have been run to the edge of the light.
(i) Do not try to remove too much waste at one time.
(j) Do not allow any overhang beyond the table when making cut.

NOTE: A new cutting wheel usually works best on sheet glass and a slightly used cutting wheel on plate glass. If the wheel is too sharp causing excessive flaking, oil the glass and use wheel with no more than ordinary pressure.



These sketches illustrate the improper and proper methods for cutting re-entrant angles in a glass plate. The sharp corners will vent or break—the arrowed curves show the correct method for making this type of cut.

The Versatility of Glass

In Art and Decoration glass has played a stellar role from the dawn of history, providing, first, beads, cameos and other articles of personal adornment, then blown ware of exquisite beauty, later magnificent colored windows and mosaics . . . today, all of these things, plus windows, lights and entire walls of daylight, with glass draperies to add to their charm.

IN the world of fashion, we find indispensable the perfection of our mirrors, the sparkling glassware on our tables. In smart shops glass mannikins give us thrilling displays of clothes. Glass jewelry provides some of our smartest adornments. Furniture and art objects of glass embellish our most richly decorated homes.

Photography that supplies millions with amusement and many with their only record of personal experience . . . which provides entertainment for millions, through the movies, and spreads the events of the entire world before every eye . . . exists only through the existence and refinement of glass for photographic purposes.

Light and illumination are provided for man's practical use when and where needed largely through the manifold services of glass. By its transparency and translucency, it transmits daylight into sheltered interiors. Through its use in lamp chimneys, lamp bulbs and in shades and globes scientifically designed to diffuse and reflect light, it permits man to project his activities into the hours of darkness.

Leisure and recreation are everywhere served by glass. Lost would we be in our leisure hours if there were no glasses for reading, no binoculars for viewing distant scenes, no lenses for cameras, no lenses for the projection of motion pictures, no glass for motor lamps and windshields, no glass containers for transporting foods and liquids on excursions and picnics.

Research of every character has become so dependent upon the services of the camera and the microscope that it would be impossible to imagine the attainment of most modern scientific objectives without these instruments that owe their

existence to glass. In laboratories, glass impervious to acid and special heat-resisting glass, make possible most of our important experiments. In libraries the lens has made available microfilm copies of the scientific books and manuscripts of all the world.

Laboratory workers find the transparency of glass and its chemically inert qualities indispensable in the various forms in which it serves them. Glass wools and cloths are used as filter media. Glass provides containers, test tubes, linings, conduits, retorts, insulators, and is a component part of various types of specialized apparatus and instruments.

Retail stores have attained merchandising efficiency largely through the employment of glass. In windows and showcases of brilliant transparency, merchandise is protected yet displayed with enhanced attractiveness. Abundant daylight or electric light illuminates interiors through the agency of glass. Glass store fronts and brilliant electric signs effectively attract customers.

Packaging has been revolutionized by the modern glass container which gives perishable products both perfect protection and effective display. Glass in opaque forms or with applied color decoration is the preferred container also for many products, even where visibility of product is entirely impossible.

Astronomy owes to the glass lenses and reflectors of the telescope most of its great achievement in the exploration of the vast reaches of the universe. Now, with the 200-inch reflector, man's range of investigation of the heavens is again tremendously extended by glass.

Exploration of the earth, itself, and the regions

in the depths of the seas has been everywhere furthered by glass. In diving equipment, glass is an essential. In the compass, the sextant and many other instruments of marine navigation, glass is indispensable. The use of airplanes and motor cars is dependent upon glass. Many of the findings of exploration are made possible by scientific instruments in which glass is an essential part.

Optics are, of course, chiefly concerned with glass. The perfection of clear, colorless glass made possible the microscope, the telescope, and all the instruments of science, industry and transportation that use lenses. Far from least of the services of glass in optics is its provision of spectacles to aid individual vision.

Medicine would not exist in its present advanced form without the aid of glass. From the fundamental discoveries and everyday analyses of the laboratories to use of syringes, hypodermic needles, fever thermometers and other such equipment of clinic and operating room, glass makes possible achievements in medicine that are of utmost value to the human race.

X-ray in all its applications, curative and exploratory, is dependent upon glass. To the X-ray tube and X-ray photography, thousands owe escape from disease and death. The X-ray tube serves mankind in the setting of bones, the extraction of steel splinters and bullets, the examination of teeth, the diagnosis of internal disorders, and the treatment of numerous skin diseases and malignant tumors.

Electricity serves man in power plant, factory and on the farm largely through the agency of glass. As a solid insulator it supports electric wires. In the form of glass fiber electrical textiles it insulates these wires and cables and enters into the improved design of motors, transformers and many instruments and power appliances. In electric light bulbs and neon tubes, its transmission of light makes possible the widespread use of electricity for illumination and display.

Communication in practically every modern form is dependent upon glass. It is an indispensable element in telephonic and telegraphic apparatus, in the radio, in television equipment, in the movie projector, in trains, motor cars, airplanes, and ships, in printing and engraving establishments and in many contributory types of equipment that serve as agencies of modern communication systems.

Signaling whether by telegraph, radio or electric light is dependent upon glass. The successful

operation of railroads, airplane lines and shipping lines, the control of motor traffic and the safety of highways are all based on the inherent characteristics of glass, its colors, its transparency, its light transmission and its electrical insulating properties. Glass can be relied upon for use in signal lanterns of definite fixed colors, and lenses of exceptionally long "carry," even though exposed to acute changes of temperature.

Air conditioning owes much of its progress to the insulating properties of glass, to its exclusion of solar heat while admitting light, to its conservation of artificial heat. Walls of glass block, double-glazed windows, Foamglas, glass fiber insulating wool and glass fiber air filters have contributed to the increased efficiency and reduced cost of air conditioning equipment and its operation.

Insulation is provided by glass in various forms. Glass stands high in efficiency as an electrical insulator. Certain types of glass filter out solar heat rays and insulate against excessive heat from the sun's radiation. Glass block and Foamglas provide insulation against passage of heat and sound. Glass fiber insulating wool is extensively used as a non-inflammable insulating material in houses and other buildings, in stoves, water-heaters and refrigerators, in trains, busses and airplanes . . . even in battleships of every class.

Building construction employs glass in an ever-increasing degree. Factory buildings, office buildings, public buildings, theaters, schools, stores and residences all gain their right to be termed modern mainly through the use of plate glass windows, walls and partitions of glass block, structural glass, double-glazed windows, skylights and partitions of fire-retardant figured and wire glass, facades of opaque colored glass, Foamglas and Fiberglas insulation in walls, roofs and floors and glass fiber acoustical products for efficient sound-quieting.

Furniture has long incorporated a certain amount of glass in its design. Sideboards, and dressing tables with their mirrors, are common. Bookcases and china cabinets have glass fronts. Glass tops for dressing tables, dining tables and desks have long been familiar. Modern all-glass furniture is now being made of heavy plate glass, structural and tempered glass, some of it having heavy glass-fabric upholstery.

Domestic equipment throughout any modern residence is composed, to an amazing degree, of glass. In tableware, kitchenware and cooking utensils, glass is predominant. In many modern

electrical appliances, glass insulates the wires and insulates against heat. Glass fiber insulation is used in refrigerators, stoves, furnaces, piping and duct work. Sight glasses of modern ranges are made of special heat-resistant glass. Shelves, vases, trays, nursing bottles and other containers are commonly of glass. In gas meters, electric meters and thermometers glass is an important component part. Foamglas insulates the walls and roofs of dwelling or factory.

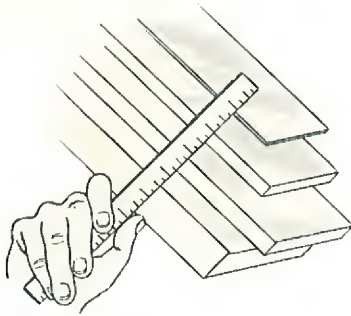
Stratosphere exploration, so important in understanding weather, so essential to the future of aviation, and possibly the forerunner of the discovery of new sources of energy, is dependent to a great degree upon glass. The delicate instruments that bring back vital information from the

outer atmosphere depend in large degree upon glass for their proper functioning.

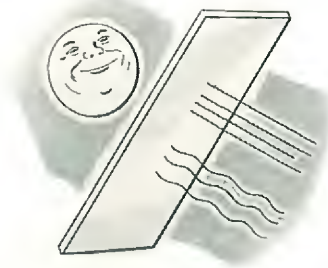
Mining employs glass in a score of ways essential to its safe and successful operation. Geographical, topographic and geological surveys, as well as chemical analysis associated with mining are all dependent on instruments employing glass lenses and other glass parts. Glass is likewise an essential in most of the electrical and ventilating equipment, power machinery, conveying equipment and illumination systems of mines.

Refrigeration requires glass for both sanitation and insulation. Glass tubes, glass shelves, glass wool and other forms of glass are constantly employed in domestic and commercial refrigeration, including railway and motor truck refrigeration.

CHARACTERISTICS OF "PITTSBURGH" GLASS



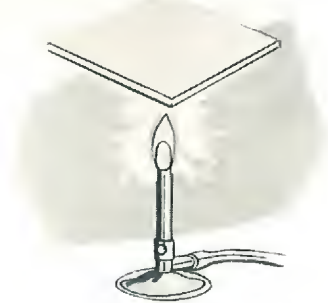
Pittsburgh Glass is available in a wide range of thicknesses from .012 inch up to 1¼ inches in single sheets. In laminated form, of course, even greater thicknesses are available.



There is a Pittsburgh Glass that absorbs 55% of the total solar heat while transmitting 70% of the solar light. There are others which filter out a substantial portion of the sun's ultra-violet rays. Others which filter out infra-red rays.



Of frequent interest to the product designer is the absolute flatness of Pittsburgh Plate Glass. The grinding and polishing technique employed in its manufacture is so efficient that the run-of-mill finished glass has superlative trueness of surface.



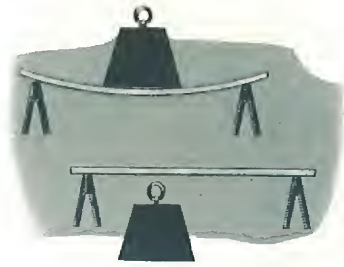
The tempering process which gives glass its great strength also substantially increases its resistance to thermal shock. Thus, Pittsburgh Glass can be made to withstand continuous temperatures of 650°F. and an instantaneous thermal shock of 400° to 450°F.



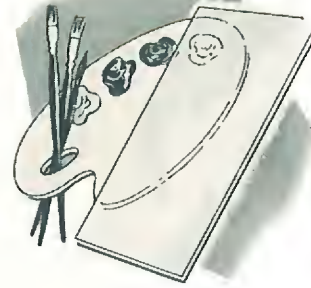
Mechanically ground and polished to a true surface, Pittsburgh Plate Glass is completely transparent. It affords perfect vision through it from any angle, whether used in thin plates or thick, in single sheet form or laminated with plastic. In window glass, Pittsburgh's Pennvernon affords an exceptionally high degree of transparency.



The physical characteristics of glass are such as to make it a durable, permanent material. Its resistance to abrasion, thermal shock, chemicals, fumes, fatigue, corrosion, etc., is now supplemented by its sheer strength and toughness achieved by tempering. Further, the colors in glass remain uniform and unfading year after year.



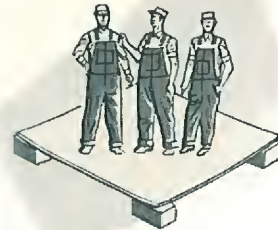
Although glass possesses surprising flexibility and elasticity, especially when tempered, it is fatigue-proof—that is, after being flexed, a light of glass always returns exactly to its original shape.



Glass today is available in a wide variety of attractive colors. Transparent plate glass is made in a soft flesh tint, in rich blue, in cool green, in water white, as well as the ordinary color. Carrara Structural Glass comes in beige, ivory, tranquil green, gray, wine, forest green, Rembrandt blue, orange, black and white.



The surface of Pittsburgh Glass can be decorated by sand-blasting, acid etching, mud grinding and honing, engraving, "Italian" processing, ceramic enameling, photo etching, chipping, and shading. It can be furnished with a brilliant, accurately reflective finish or with a softer "suede" finish.



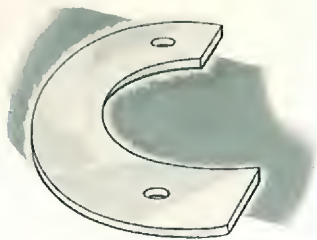
Pittsburgh Glass when tempered is given greatly increased toughness, strength, flexibility and resistance to shock and impact. Tempering makes glass approximately four times as strong and flexible as untempered glass, many times as resistant to shock. The tensile strength of tempered glass is 29,500 lbs. per sq. in. of cross section.



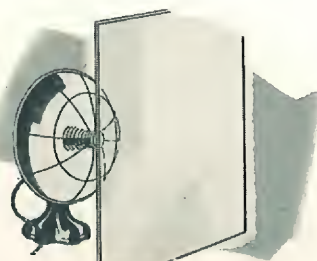
In recent years, research and experimentation have resulted in advanced methods of bending and shaping glass. Shapes formerly thought impossible can now be achieved, both in single and laminated sheets of glass.



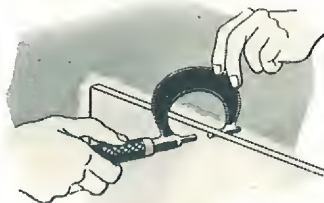
Tempered Pittsburgh glass provides four to five times the protection against shattering found in ordinary untempered glass. And Pittsburgh Laminated Safety Glasses, ranging from 1/8 inch thicknesses up to the heavy bullet-resisting glasses, provide outstanding protection in a multitude of applications.



Pittsburgh Glass can be cut to pattern, drilled with holes, notched and edge-finished depending upon your requirements. The fabrication possibilities of glass have developed with amazing rapidity in recent years.



Glass has lower heat transmission than most metals. Depending on the glass product, its thermal conductivity (K) at 120°F. ranges from 4.61 to 6.674 B.T.U. per square foot per hour per inch of thickness per degree F.



Glass has a very low coefficient of expansion. Depending upon what glass product is used, its coefficient of linear expansion ranges from (°C.), 7.30×10^{-6} to 8.34×10^{-6} ; (°F.), from 4.05×10^{-6} to 4.63×10^{-6} .



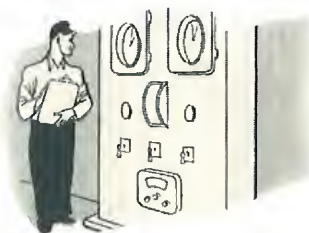
Pittsburgh Glass is non-porous and non-absorptive, and has a hard, smooth, dense surface. It is, therefore, exceedingly sanitary, and easy to keep clean.



The surface structure of glass is hard, dense, smooth and brilliant. It is, therefore, exceptionally resistant to abrasion and surface scratches. Depending on the glass product, hardness ranges from 5.5 to 7 (Mohs' scale).



Glass is absolutely non-porous and non-absorptive. This means that acids, alkalis, chemicals, liquids of almost every kind affect it not at all... a valuable property in many product applications.



Glass has unique dielectric properties. It is an inert material with high insulation value, making it ideal for many product applications involving electricity.

SECTION "J"

TECHNICAL DATA

J-1

POLISHED PLATE GLASS

J-2

CARRARA GLASS

J-3

WINDOW GLASS

J-4

BENT GLASS

J-5

LAMINATED SAFETY GLASS

J-6

MIRRORS

J-7

CERAMIC ENAMELED GLASS

J-8

LIGHTING GLASS

J-9

ROUGH ROLLED GLASS

J-10

PC GLASS BLOCKS

J-11

PC FOAMGLAS

J-12

MISSISSIPPI GLASS

J-13

PRESSED PRISM PLATE GLASS

TECHNICAL J
DATA

Technical Data

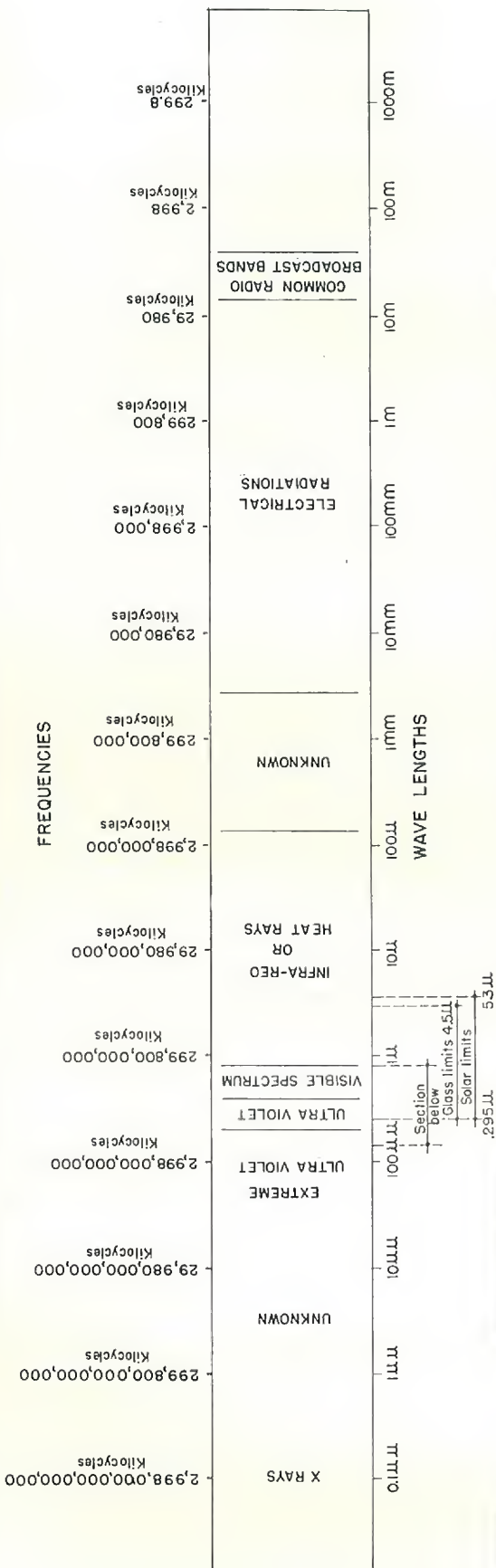
In this section will be found technical data covering all of the several flat glass products of the Pittsburgh Plate Glass Company. The tables include general engineering information as well as charts of visible and invisible radiant energy transmission and other data of interest such as wind loads, safe operating loads for flat glass, dance floor plate sizes, etc.

Other glass products of the Company, the Pittsburgh Corning Corporation, the Mississippi Glass Company, and the Pressed Prism Plate Glass Company will be found in other subdivisions of the main J section.

RELATIVE WAVE LENGTHS OF DIFFERENT FORMS OF RADIANT ENERGY AND CORRESPONDING FREQUENCIES

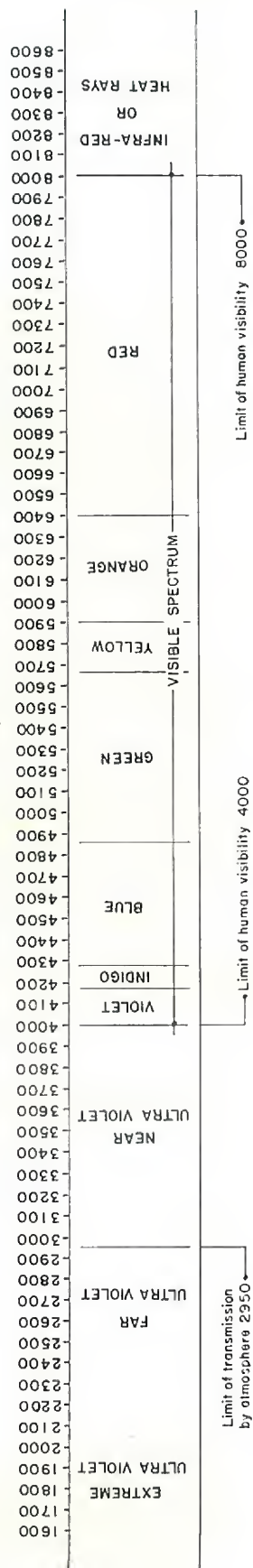
VELOCITY OF RADIANT ENERGY 186,000 MILES OR 299,800 KILOMETERS PER SECOND

1 KM = 1000M
1 KM = 0.61 MILE
1M = 1000MM
1MM = 1000μ (MICRONS)
1μ = 1000mμ (MILLIMICRONS)
1 ANGSTROM UNIT = 100mμ



ENLARGED SCALE OF VISIBLE SPECTRUM AND ULTRA-VIOLET

SCALE IN ANGSTROM ONE ANGSTROM UNIT = 0.0000001M OR 0.00000004 INCH



Polished Plate Glass

REGULAR POLISHED PLATE GLASS

REGULAR PLATE

Available in:

$\frac{7}{64}$ " and $\frac{1}{8}$ " thick in plate sizes up to 72" long by 123" wide.
 $\frac{7}{32}$ " thick in plate sizes up to 123" long by 216" wide.
 $\frac{1}{4}$ " thick in plate sizes up to 160" long by 220" wide.
 $\frac{1}{4}$ " thick in plate sizes up to 150" long by 260" wide.

HEAVY PLATE

Available in:

$\frac{3}{8}$ " and $\frac{1}{2}$ " thick in plate sizes up to 72" long by 160" wide;
 160" x 220"; 150" x 260".
 $\frac{5}{8}$ ", $\frac{3}{4}$ ", $\frac{7}{8}$ " and 1" thick in plate sizes up to 72" long by
 130" wide.
 $1\frac{1}{4}$ " thick in plate sizes up to 70" long by 130" wide.

All clear glass plates with faces nearly optical planes and almost exactly parallel, thoroughly defined by the U. S. Federal Specifications DD-G-451.

PROPERTIES:

The general properties of polished plate glass, as determined on standard factory production (as to composition, finish and anneal) are as follows:

Tensile (determined as Modulus of Rupture) ultimate.....6,500 lbs./sq. in. of cross section
 Compression strength (1 inch cube)..... 36,000 lbs./sq. in.
 Modulus of elasticity10,000,000 lbs./sq. in.
 (Young's modulus)
 Hardness (Moh's scale) (Diamond—10,
 Sapphire—9, etc.).....5.5—6.5

Specific Gravity (70°F.)2.520
 Weight/sq. ft./inch of thickness.....13.16 lbs.
 Light transmission ($\frac{1}{4}$ " thickness)
 Total visible white light.....88.2%
 Total radiant energy transmission ($\frac{1}{4}$ " thickness)....77.4%
 Total solar infra-red.....67.8%
 Total solar ultra-violet.....66.3%
 Softening point.....1350°F.
 Coefficient of
 linear expansion.....(°C.) 8.02×10^{-6} ; (°F.) 4.45×10^{-6}
 Thermal conductivity (K.) at 120°F.
6.67-l (B.t.u./sq. ft./hr./inch of thickness/degree F.)
 Thermal conductance (U.) single plate
 (Air to air).....1.13 (B.t.u./sq. ft./hr./degree F.)
 Specific heat (0—100°C.; 32°—212°F.).....0.205
 Thermal endurance
 (Heat shock to rupture 2" x 2" x $\frac{7}{32}$ " samples, heated to a
 higher temperature and instantly plunged into water
 at 70°F.).....100°F. differential)
 Generally resistant to most acids and other chemicals
 Solubility (boiling one hour, distilled water, 60 mesh sample)
 Total solids.....0.167%
 Total alkali.....0.050%

Chart and table of safe loads and sizes on subsequent pages. Regardless of superficial area, the greatest uniformly distributed load which any square light of annealed glass, 1 inch thick (supported on all 4 sides) will support, is 21,000 lbs. The strength of glass varies as the square of the thickness.

Because of many factors affecting strength of glass and the wide variation between minimum and maximum strength determinations, Pittsburgh Plate Glass Company will be glad to discuss safety factors.

MAXIMUM GLASS SIZES** OF VARIOUS THICKNESSES FOR GLAZING VERTICAL WINDOWS SUPPORTED ON FOUR SIDES

SQUARE FEET OF AREA

Glass Thickness	†† SS-.087"	†† DS-.118"	$\frac{1}{8}$ "	$\frac{3}{16}$ "	$\frac{1}{4}$ "	$\frac{5}{16}$ "	$\frac{3}{8}$ "	$\frac{1}{2}$ "	$\frac{5}{8}$ " up to 1"	$1\frac{1}{4}$ "
30 Mile Wind	35 sq. ft.†	64.5†	72†	162	°244	°244				
40 Mile Wind	17.5†	32.25†	36†	81	144	225	°244			
55 Mile Wind	11.6	21.5†	24†	54	96	150	216			
65 Mile Wind	8.7	16.1†	18†	41	72	112	162	°244		
80 Mile Wind	5.8	10.85	12	27	48	75	108	192		
100 Mile Wind	3.5	6.45	7	16	29	45	65	115		
120 Mile Wind	2.5	4.6	5	11	20	32	46	82	°65	°63

†"SS", "DS" and $\frac{1}{8}$ " glass, because of flexibility, should never be used in areas exceeding 12 square feet, and for the sake of appearance, areas used should not exceed 7 square feet.

††"SS" means Single Strength; "DS" means Double Strength; both apply to window glass.

°Maximum size available.

°°These sizes are based on practical experience and are entirely adequate. They should not be referred to the Chart of Safe Loads for Plate Glass since in actual use, due to intermittent loading, the actual factor of Safety is several times the apparent values.

NITRATE PLATE GLASS, 1/4 INCH

Available in: 1/4" thick plates up to 123" long by 216" wide.

PROPERTIES:

Essentially the same as those for plate glass.

HERCULITE (TEMPERED) PLATE GLASS

Available in:

1/4" to 1 1/4" thick plates up to 72" long by 108" wide in the glasses described in the preceding and most of those in the following sections.

PROPERTIES:

The properties of Herculite vary with the particular glass product which has been subjected to the tempering process. The following values apply specifically to the regular plate glass product and not to the specialized products separately described. In general, the tempering process producing Herculite Glass affects only the modulus of rupture, the hardness and the thermal endurance of the glass. Thus, for regular Herculite Plate Glass:

Tensile (determined as Modulus of Rupture)
ultimate.....29,500 lbs./sq. in. of cross section
Hardness (Moh's scale).....7
Thermal endurance.....400°F. differential
Safe WORKING TEMPERATURE (Maximum).....650°F.
(Any Herculite Tempered product)

Modulus of rupture for any Herculite tempered product may be taken as essentially 4.5 times the modulus of rupture of the annealed product. Regardless of superficial area, the greatest uniformly distributed load which any square light of Herculite, 1 inch thick (supported on all 4 sides) will support, is 94,500 pounds. The strength varies as the square of the thickness.

*CRYSTALEX PLATE GLASS

Available in: 1/4" thick plates up to 123" long by 216" wide.

PROPERTIES:

Approximately same as for plate glass except as noted below:

Softening point1390°F.
Total visible white light transmission.....91.0%
Total radiant energy transmission (1/4" thickness).....90.6%
Total solar infra-red.....90.3%
Total solar ultra-violet.....83.5%
Solubility (boiling one hour, distilled water, 60 mesh sample)
Total solids0.320%
Soluble alkali0.070%

*Note: Crystalex has the highest visible and total energy transmission of any plate glass product available on the market.

Because of unusually high transmission in the ultra-violet, this glass is exceptionally useful for photographic and blue-print purposes.

WATER WHITE PLATE GLASS

Available in: 1/4" thick plates up to 123" long by 216" wide.

PROPERTIES:

Approximately same as for plate glass except as noted below:

Softening point1380°F.
Total visible white light transmission.....90%

Total radiant energy transmission.....90%
Total solar ultra-violet.....83%
Total solar infra-red.....90%
Solubility (boiling one hour, distilled water, 60 mesh sample)
Total solids.....0.320%
Soluble alkali0.070%
Because of unusually high transmission in the ultra-violet, this glass is exceptionally useful for photographic and blue-print purposes.

BLUE PLATE

Available in: 13/64" thick plates up to 123" long by 216" wide.

PROPERTIES:

In general, the properties of blue plate glass are identical with those of regular plate glass, except for radiant energy transmission.

FLESH-TINTED PLATE

Available in: 13/64" thick plates up to 123" long by 216" wide.

PROPERTIES:

In general, the properties of flesh-tinted plate glass are identical with those of polished plate glass except for radiant energy transmission.

SOLEX (HEAT-ABSORBING) PLATE GLASS

Solex R { In 1/4" thick plates up to 123" long by 216" wide.
In 3/8" thick plates up to 72" long by 130" wide.
Solex S In 1/8" thick plates 123" long by 216" wide.

This glass is obtainable in 2 different compositions such that Solex S in 1/8 inch thickness shall have transmissions equal to those of Solex R in 1/4 inch thickness.

PROPERTIES:

Approximately same as for plate glass except as noted below:

Light transmission
Solex R in 1/4" thickness and Solex S in 1/8" thickness
Total visible white light.....70-75%
Total solar energy.....39-45%
Total solar infra-red.....13-19%
Total solar ultra-violet.....26-40%
Softening point1317°F.
Coefficient of
linear expansion.....(°C.) 8.34×10^{-6} ; (°F.) 4.63×10^{-6}
Thermal endurance.....125°F. differential
Solubility (boiling one hour, distilled water, 60 mesh sample)
Total solids.....0.258
Total alkali.....0.072
Specific heat (0-100°C., 32°-212°F.).....0.220

X-RAY LEAD PLATE GLASS

Available only in:

5.35 to 7.35 mm. thick plates up to 40" long by 72" wide.

The X-Ray Lead Glass produced by the Pittsburgh Plate Glass Company has a lead content of approximately 61 per cent, and a lead equivalent value of .32 as determined by the U. S. Bureau of Standards. This glass is being produced at present in 1 thickness only, viz., 5.35 to 7.35 mm., which is equivalent to at least 1/16 inch sheet lead at 100 Kv.

X-Ray Lead Glass weighs approximately twice as much as regular plate or window glass. It is available in glazing quality and in photographic quality. Ordinarily, this glass should be laminated with a cover of plate glass to prevent deterioration of the surfaces by abrasion or atmospheric corrosion.

PROPERTIES:

The index of refraction of X-Ray Lead Glass is very high at 1.7608.

(This value is exceptionally high for glasses and is quoted here for that reason.)

Coefficient of linear expansion	(°C.) 7.30×10^{-6} ; (°F.) 4.05×10^{-6}
Softening point	1155°F.
Lead equivalent (at 100 Kv.), guaranteed min.	0.30
Light transmission, avg. thick. 6.35 mm. = 1/4 inch	
Total visible white light	84.9%
Total radiant energy	81.5%
Total solar ultra-violet	12.1%
Ultra-violet (0.350 microns and shorter)	00.0%
Solar infra-red	82.6%
Thermal conductivity (K) at 120°F.	
	4.61 (B.t.u./sq. ft./hr./inch of thickness/degree/F.)
Tensile (determined as Modulus of Rupture)	5,000 lbs./sq. in. cross section
Modulus of elasticity	8,000,000 lbs./sq. in.
Specific heat (0–100°C.; 32–212°F.)	0.093
Specific gravity (70°F.)	4.879
Hardness (Moh's scale)	5
Thermal endurance	100°F. differential
Solubility (boiling one hour, distilled water, 60 mesh sample)	
Total solids	0.05
Alkali	0.005
Average weight (6.35 mm. average thickness)	6.37 lbs./sq. ft.

PROTECTION VALUE OF VARIOUS THICKNESSES

X-Ray Lead Glass has a lead coefficient of at least .30 at 100 Kv. on the X-Ray tube and, in the various thicknesses, will have the lead equivalent values shown in this table.

1 Light, only			
Thickness	Min.	Avg.	Max.
Millimeters	5.35	6.35	7.35
Inches	.211	.25	.289
Lead Equivalent (Minimum)			
Millimeters	1.60	1.90	2.20
Inches	.0633	.075	.086
# per sq. ft.	3.741	4.436	5.086
Min. Light Transmission—86%			
2 Lights, Laminated			
Thickness			
Millimeters	11.08	13.08	15.08
Inches	.437	.515	.593
Lead Equivalent (Minimum)			
Millimeters	3.2	3.8	4.4
Inches	.126	.150	.172
# per sq. ft.	7.452	8.87	10.17
Min. Light Transmission—80%			
3 Lights, Laminated			
Thickness			
Millimeters	16.81	19.81	22.81
Inches	.663	.780	.897
Lead Equivalent (Minimum)			
Millimeters	4.8	5.7	6.6
Inches	.189	.225	.258
# per sq. ft.	11.18	13.30	15.25
Min. Light Transmission—75%			

Ultra-violet transmission Wave-length (microns)	Transmission Factor approximate
0.400	47%
0.390	32%
0.380	18%
0.370	6%
0.360	0.8%
0.350	0.0%

RADIANT ENERGY TRANSMISSION DATA

On the following pages will be found charts and tables showing the spectral transmission of all of the standard polished plate glass products of the Pittsburgh Plate Glass Company. These tables and charts are derived from data prepared in the Research Laboratory of the Pittsburgh Plate Glass Company. The data shown are presented as typical of the Company products and do not in any way constitute guaranteed transmission values. The same symbols are used on all of the charts to indicate ultra-violet, visible or infra-red transmission values. Ultra-violet covers the entire range of radiant energy having a wave length shorter than 400 millimicrons down to the lower limit of solar radiation at 292 millimicrons; visible light comprises radiation of all wave lengths from 400 millimicrons to at least 750 millimicrons while infra-red comprises all radiation from 750 millimicrons to at least 100 microns.

LEGEND FOR CHARTS

- Ultra Violet, up to 400 mmu.
- Visible, beyond 400 mmu.
- Infra-red, 750-3000 mmu.

RADIANT ENERGY TRANSMISSION

ULTRA-VIOLET		VISIBLE		INFRA-RED	
Wave-length MMU	Per cent Transmission	Wave-length MMU	Per cent Transmission	Wave-length MMU	Per cent Transmission
300	1.1	400	87.2	800	71.4
310	0.3	420	87.5	900	65.8
320	0.3	440	87.3	1000	63.4
330	6.2	460	88.7	1100	62.9
340	29.4	480	89.3	1200	63.8
350	57.4	500	89.4	1300	68.6
360	74.8	520	89.5	1400	69.9
370	81.7	540	89.3	1500	71.1
380	79.3	560	88.7	1600	73.8
390	83.7	580	88.0	1700	75.5
		600	87.0	1800	75.9
		620	85.6	1900	76.1
		640	84.4	2000	77.1
		660	83.0	2100	76.3
		680	81.3		
		700	79.6		
		720	77.9		
		740	76.1		
		750	75.3		

Thickness of sample..... .265"

Average

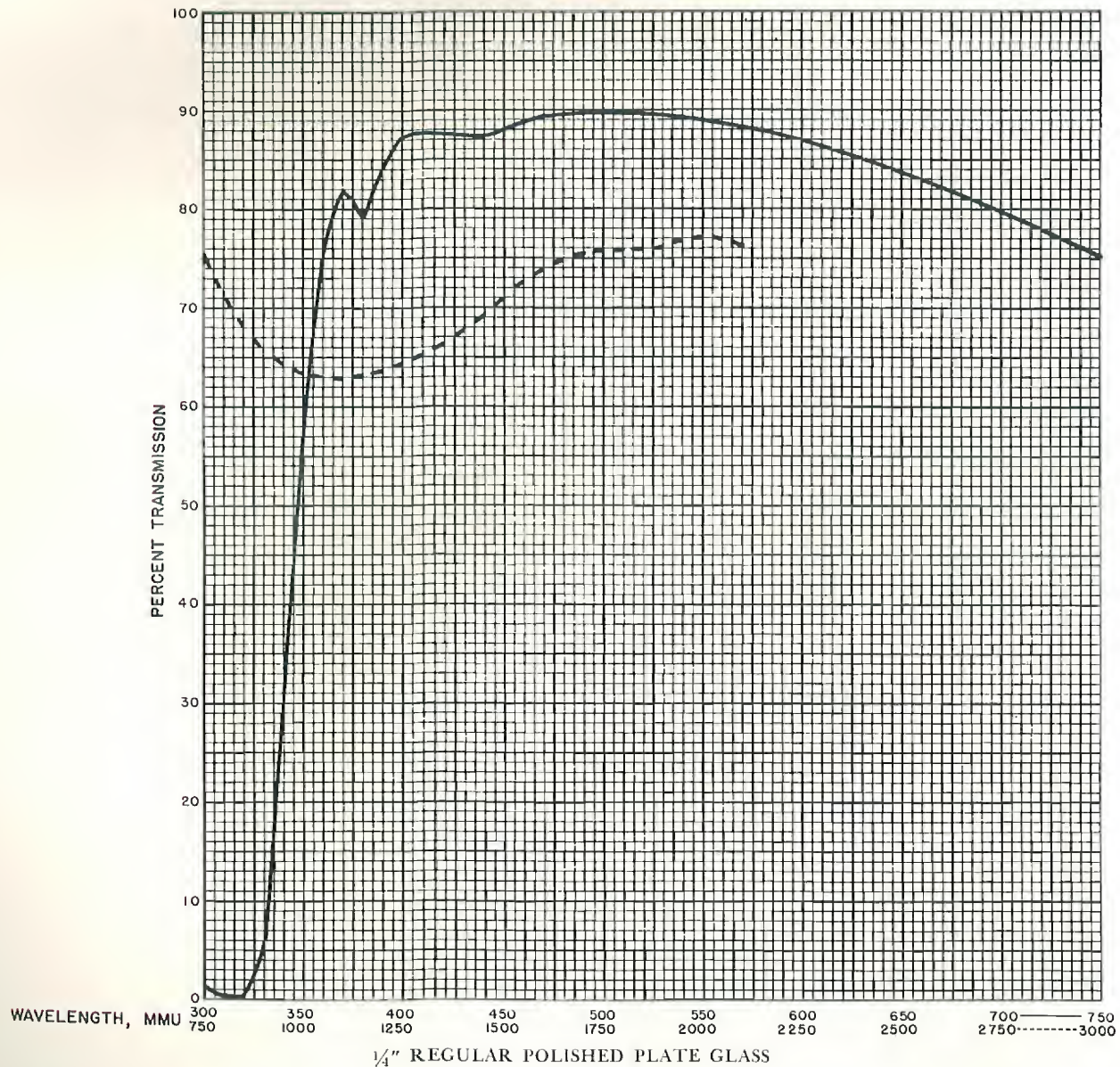
Total solar light.....88.2%

Total solar energy (calculated).....77.4%

Total solar ultra-violet.....66.3%

Total solar infra-red.....67.8%

SPECTRAL TRANSMISSION

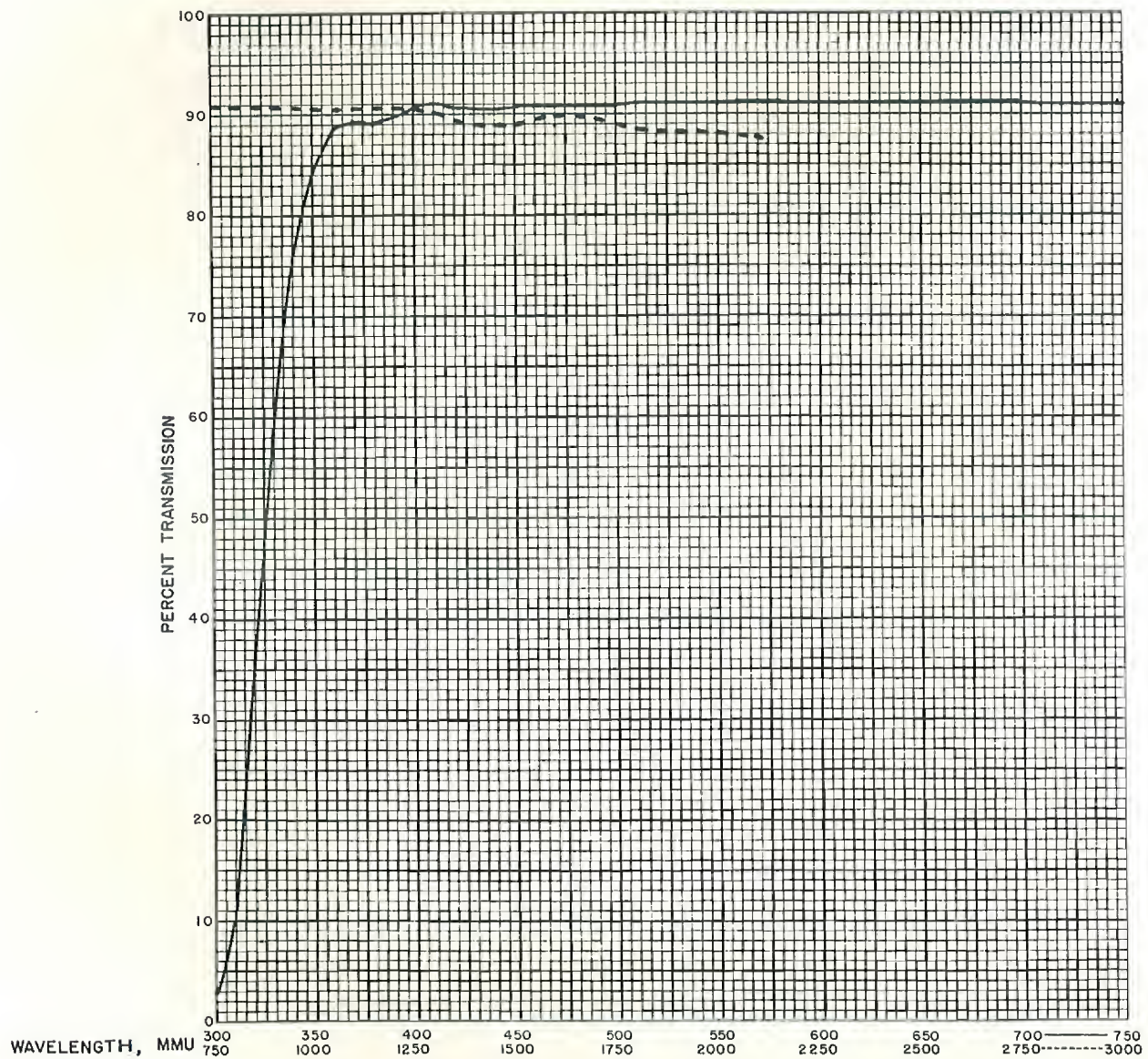


RADIANT ENERGY TRANSMISSION

ULTRA-VIOLET		VISIBLE		INFRA-RED	
Wave-length MMU	Per cent Transmission	Wave-length MMU	Per cent Transmission	Wave-length MMU	Per cent Transmission
300	3.0	400	90.4	800	90.8
310	11.6	420	90.5	900	90.8
320	34.4	440	90.4	1000	90.4
330	58.7	460	90.8	1100	90.4
340	75.4	480	90.8	1200	90.5
350	83.8	500	90.8	1300	90.1
360	88.4	520	91.1	1400	88.9
370	89.3	540	91.1	1500	88.9
380	89.0	560	91.2	1600	89.9
390	89.7	580	91.1	1700	89.6
		600	91.1	1800	88.4
		620	91.1	1900	88.2
		640	91.1	2000	88.1
		660	91.1	2100	87.8
		680	91.1		
		700	91.0		
		720	90.9		
		740	90.9		
		750	90.9		

Thickness of sample..... .250"
Average
Total solar light.....91.1%
Total solar energy (calculated).....90.6%
Total solar ultra-violet.....83.5%
Total solar infra-red.....90.3%

SPECTRAL TRANSMISSION



1/4" CRYSTALEX POLISHED PLATE GLASS

RADIANT ENERGY TRANSMISSION

ULTRA-VIOLET		VISIBLE		INFRA-RED	
Wave-length MMU	Per cent Transmission	Wave-length MMU	Per cent Transmission	Wave-length MMU	Per cent Transmission
300	3.5	400	90.5	800	91.0
310	12.0	420	90.6	900	91.0
320	35.3	440	90.8	1000	90.9
330	58.5	460	90.8	1100	90.7
340	74.6	480	91.1	1200	90.4
350	83.0	500	91.1	1300	89.7
360	86.9	520	91.1	1400	87.3
370	89.0	540	91.1	1500	85.8
380	88.3	560	91.1	1600	86.0
390	89.5	580	91.1	1700	84.9
		600	91.2	1800	85.6
		620	91.3	1900	84.5
		640	91.1	2000	85.1
		660	91.1	2100	84.1
		680	91.1		
		700	91.1		
		720	91.0		
		740	91.0		
		750	91.0		

Thickness of sample..... .239"

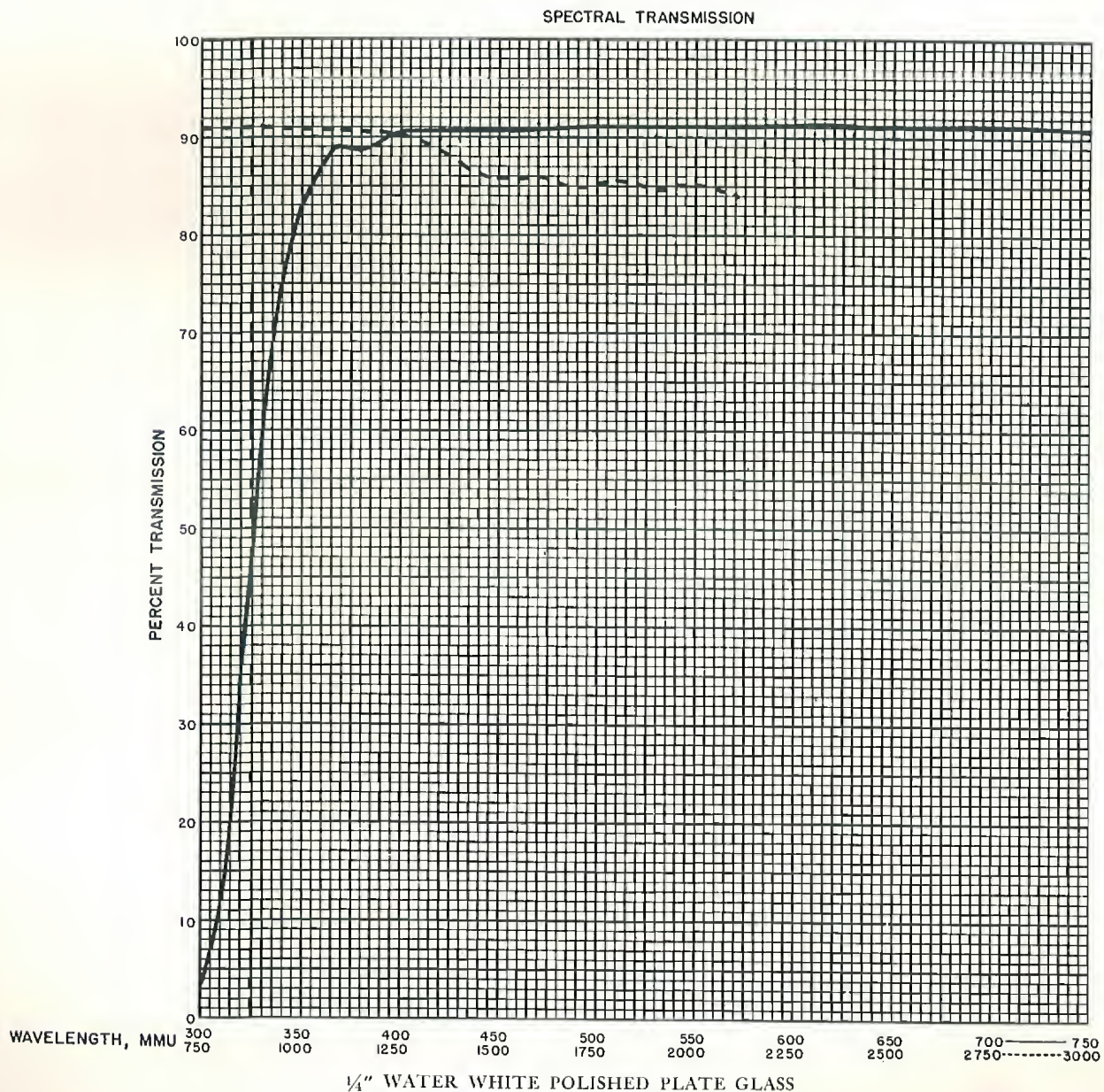
Average

Total solar light.....91%

Total solar energy (calculated).....90%

Total solar ultra-violet.....83%

Total solar infra-red.....90%

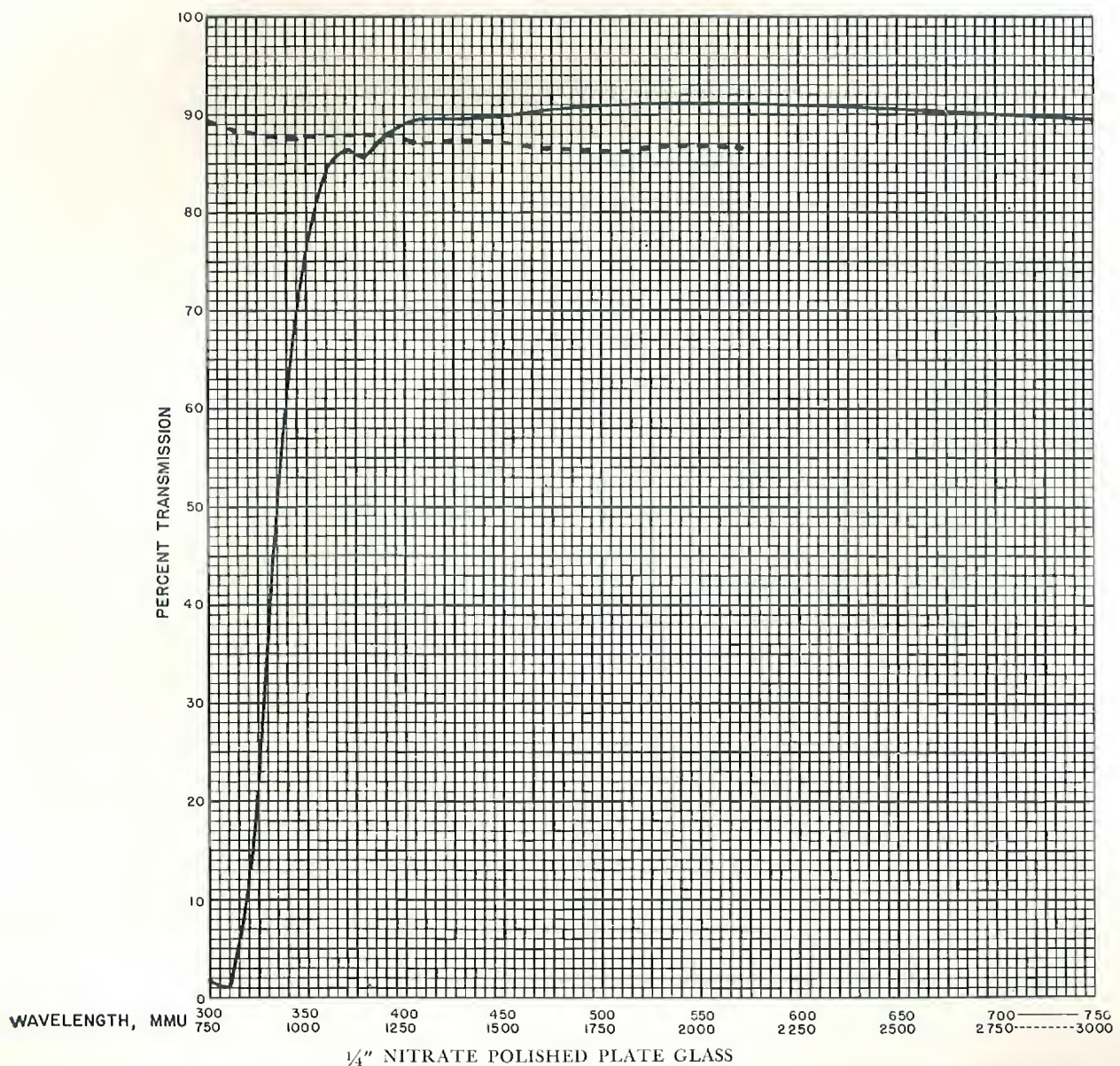


RADIANT ENERGY TRANSMISSION

ULTRA-VIOLET		VISIBLE		INFRA-RED	
Wave-length MMU	Per cent Transmission	Wave-length MMU	Per cent Transmission	Wave-length MMU	Per cent Transmission
300	1.5	400	89.1	800	88.5
310	1.1	420	89.8	900	88.0
320	11.3	440	89.6	1000	87.8
330	34.9	460	90.4	1100	87.9
340	60.3	480	90.5	1200	87.9
350	75.9	500	90.5	1300	87.0
360	84.0	520	90.8	1400	87.2
370	86.3	540	91.1	1500	87.1
380	85.8	560	91.1	1600	86.5
390	87.9	580	91.1	1700	86.3
		600	90.9	1800	86.1
		620	90.7	1900	86.7
		640	90.3	2000	86.8
		660	90.2	2100	86.5
		680	90.2		
		700	89.7		
		720	89.6		
		740	89.6		
		750	89.3		

Thickness of sample..... .253"
 Average
 Total solar light.....90.5%
 Total solar energy (calculated).....89%
 Total solar ultra-violet.....77%
 Total solar infra-red.....88%

SPECTRAL TRANSMISSION



RADIANT ENERGY TRANSMISSION

ULTRA-VIOLET		VISIBLE		INFRA-RED	
Wave-length MMU	Per cent Transmission	Wave-length MMU	Per cent Transmission	Wave-length MMU	Per cent Transmission
300	1.5	400	88.1	800	86.4
310	0.5	420	86.3	900	84.3
320	6.9	440	83.9	1000	82.1
330	27.8	460	79.6	1100	78.1
340	55.1	480	68.5	1200	72.3
350	72.7	500	54.5	1300	74.6
360	81.8	520	42.3	1400	62.5
370	85.5	540	39.0	1500	62.9
380	84.2	560	46.6	1600	62.3
390	86.3	580	33.9	1700	62.2
		600	24.9	1800	62.6
		620	27.8	1900	63.5
		640	27.4	2000	64.5
		660	28.6	2100	64.6
		680	42.8		
		700	69.3		
		720	83.2		
		740	86.7		
		750	86.7		

Thickness of sample..... .238"

Average

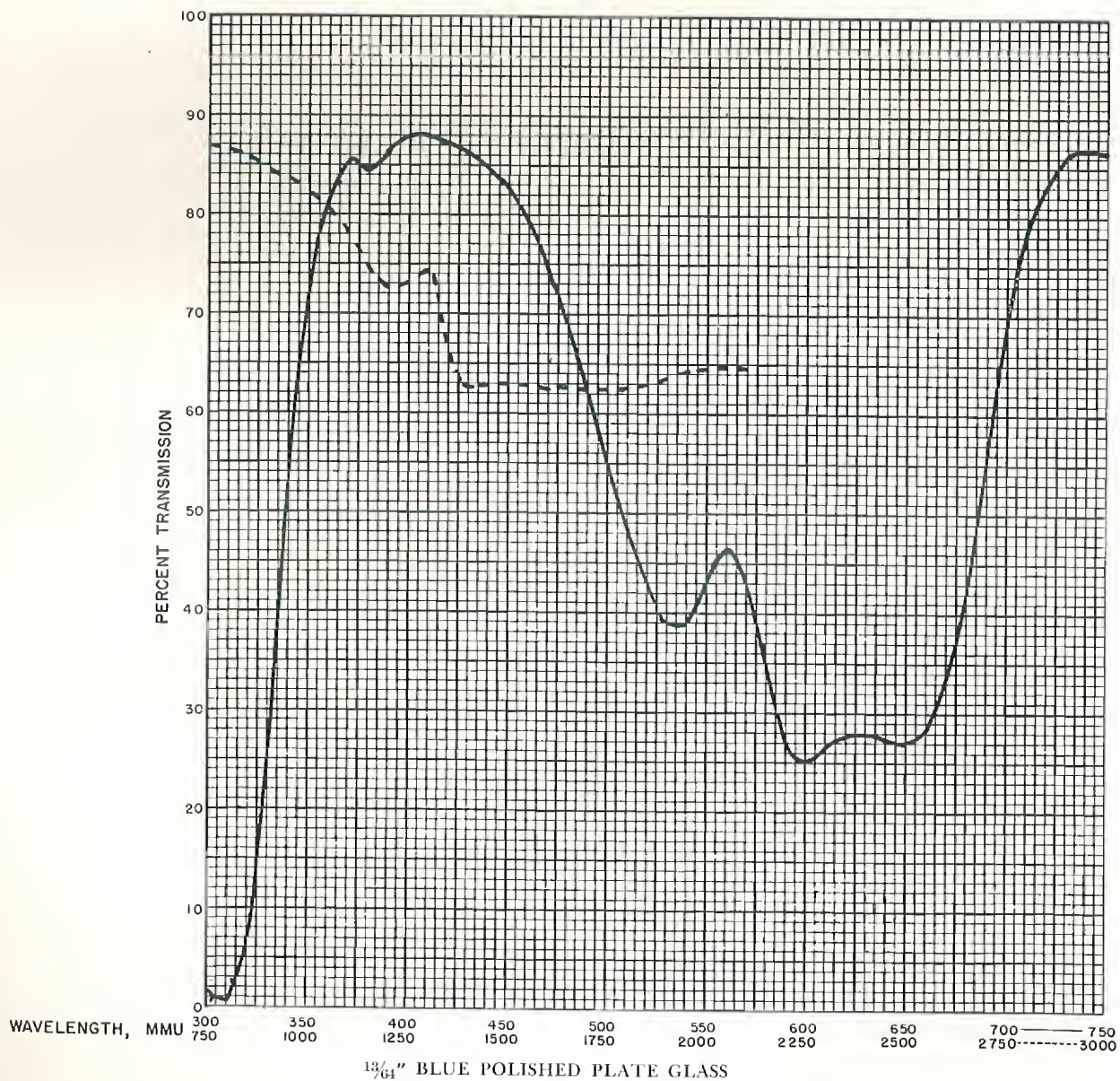
Total solar light.....39%

Total solar energy (calculated).....65%

Total solar ultra-violet.....75%

Total solar infra-red.....78%

SPECTRAL TRANSMISSION

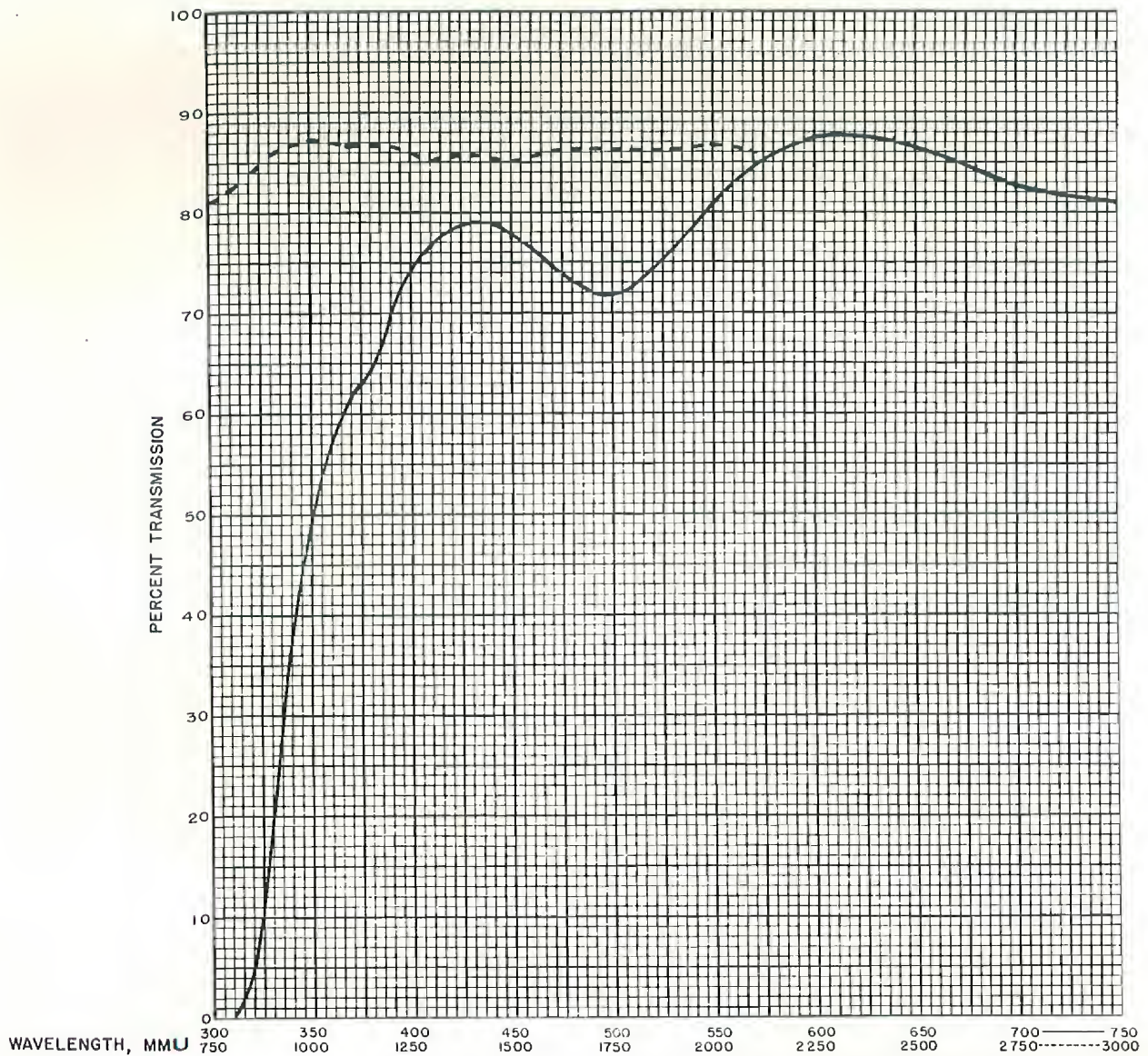


RADIANT ENERGY TRANSMISSION

ULTRA-VIOLET		VISIBLE		INFRA-RED	
Wave-length MMU	Per cent Transmission	Wave-length MMU	Per cent Transmission	Wave-length MMU	Per cent Transmission
300	0.5	400	74.4	800	82.2
310	0.0	420	78.2	900	85.8
320	4.7	440	79.0	1000	87.3
330	19.4	460	76.7	1100	86.8
340	37.0	480	73.1	1200	86.7
350	48.6	500	71.7	1300	85.0
360	56.2	520	74.2	1400	85.7
370	61.4	540	78.4	1500	85.1
380	64.2	560	82.8	1600	86.1
390	69.7	580	85.7	1700	86.3
		600	87.4	1800	86.2
		620	87.5	1900	86.2
		640	87.3	2000	86.7
		660	85.8	2100	86.0
		680	84.5		
		700	82.7		
		720	81.9		
		740	81.3		
		750	81.0		

Thickness of sample..... 221"
Average..... 80%
Total solar light..... 80%
Total solar energy (calculated)..... 80%
Total solar ultra-violet..... 57%
Total solar infra-red..... 83%

SPECTRAL TRANSMISSION

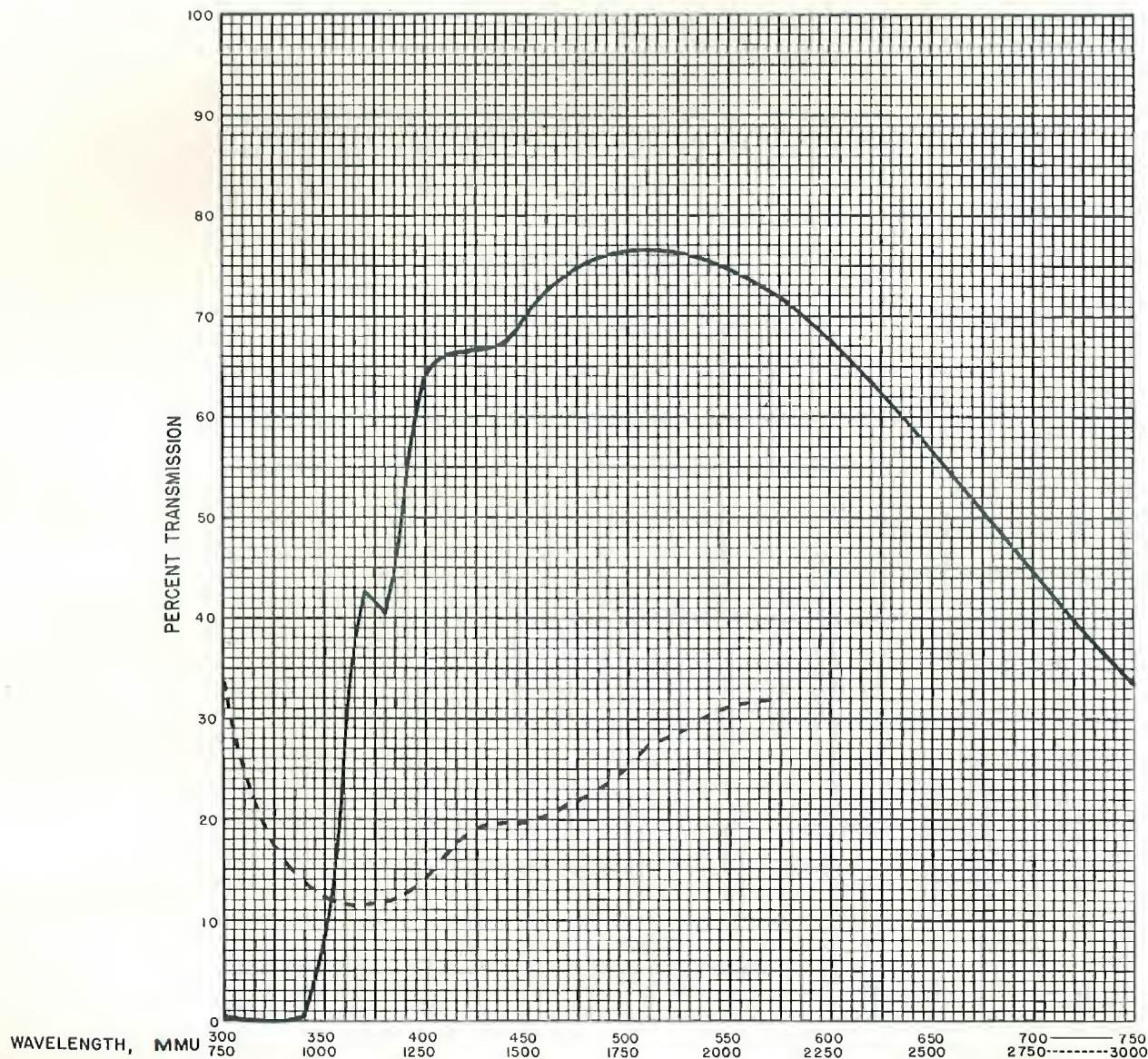


RADIANT ENERGY TRANSMISSION

ULTRA-VIOLET		VISIBLE		INFRA-RED	
Wave-length MMU	Per cent Transmission	Wave-length MMU	Per cent Transmission	Wave-length MMU	Per cent Transmission
300	0.4	400	64.0	800	25.3
310	0.1	420	66.6	900	15.8
320	0.0	440	67.4	1000	12.2
330	0.0	460	72.7	1100	11.5
340	0.5	480	75.3	1200	12.7
350	8.4	500	76.2	1300	16.5
360	27.3	520	76.5	1400	19.5
370	42.6	540	75.4	1500	19.7
380	40.6	560	73.7	1600	21.6
390	53.0	580	71.2	1700	23.6
		600	67.7	1800	27.3
		620	63.6	1900	29.1
		640	58.8	2000	31.1
		660	54.4	2100	31.9
		680	49.1		
		700	44.1		
		720	39.6		
		740	35.6		
		750	33.5		

Thickness of sample..... .118"
 Average
 Total solar light.....72.4%
 Total solar energy (calculated).....42.3%
 Total solar ultra-violet.....31.2%
 Total solar infra-red.....18.2%

SPECTRAL TRANSMISSION



1/8" SOLEX HEAT ABSORBING PLATE GLASS

RADIANT ENERGY TRANSMISSION

ULTRA-VIOLET		VISIBLE		INFRA-RED	
Wave-length MMU	Per cent Transmission	Wave-length MMU	Per cent Transmission	Wave-length MMU	Per cent Transmission
300	0.5	400	68.3	800	26.2
310	0.1	420	70.0	900	16.8
320	0.0	440	70.0	1000	13.1
330	0.0	460	75.6	1100	12.2
340	0.4	480	78.1	1200	13.3
350	8.2	500	79.0	1300	17.0
360	29.7	520	79.2	1400	21.7
370	46.4	540	78.2	1500	19.9
380	41.8	560	76.2	1600	23.3
390	51.2	580	73.7	1700	27.0
		600	70.0	1800	26.4
		620	65.8	1900	29.9
		640	61.1	2000	33.0
		660	56.1	2100	31.4
		680	50.9		
		700	45.8		
		720	41.2		
		740	36.8		
		750	35.0		

Thickness of sample..... .248"

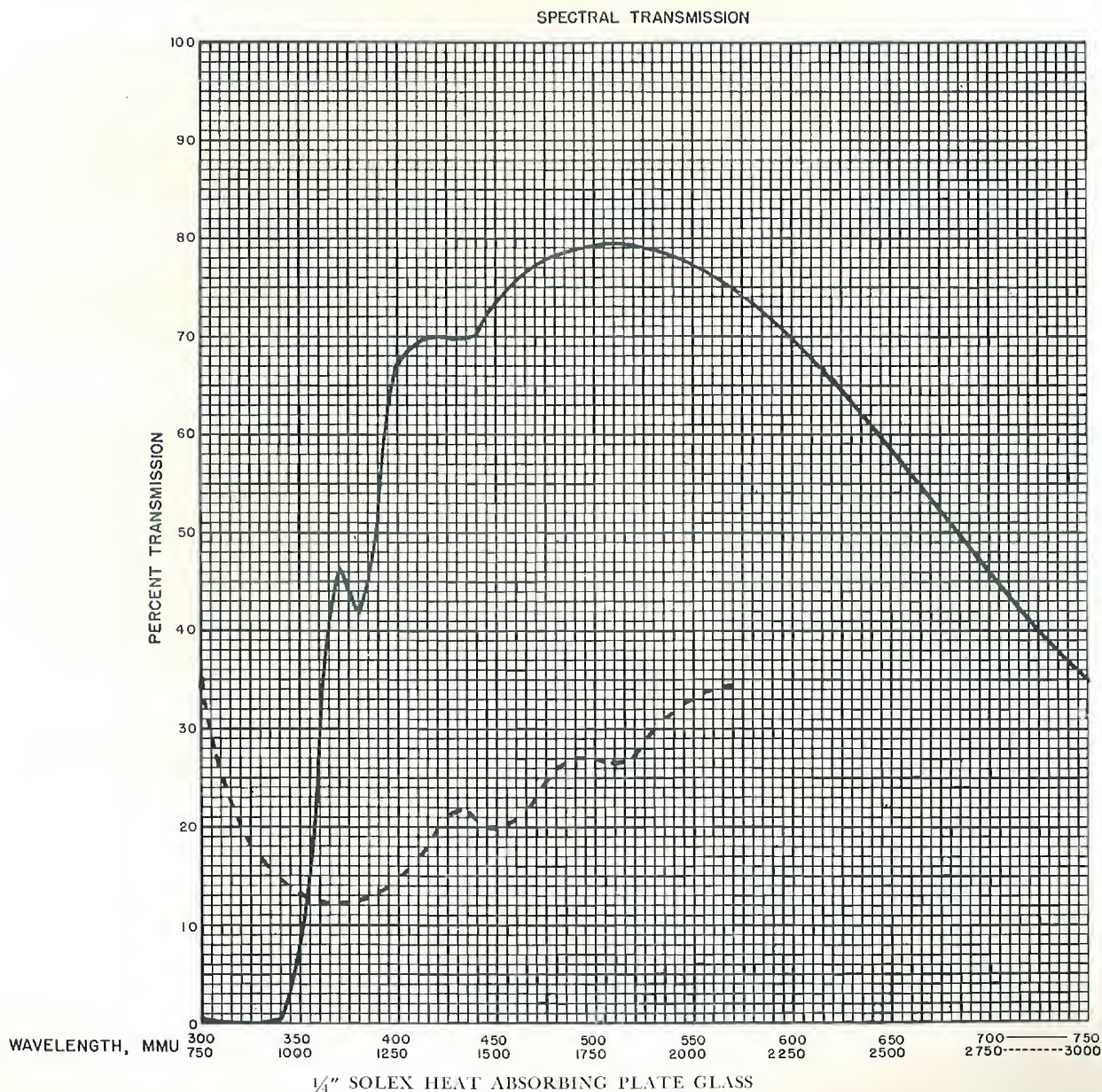
Average

Total solar light.....74.1%

Total solar energy (calculated).....41.1%

Total solar ultra-violet.....31.9%

Total solar infra-red.....19.1%



RADIANT ENERGY TRANSMISSION

ULTRA-VIOLET

Wave-length MMU	Per cent Transmission
300	0.0
310	0.0
320	0.0
330	0.0
340	0.0
350	4.2
360	22.8
370	39.9
380	34.6
390	39.0

VISIBLE

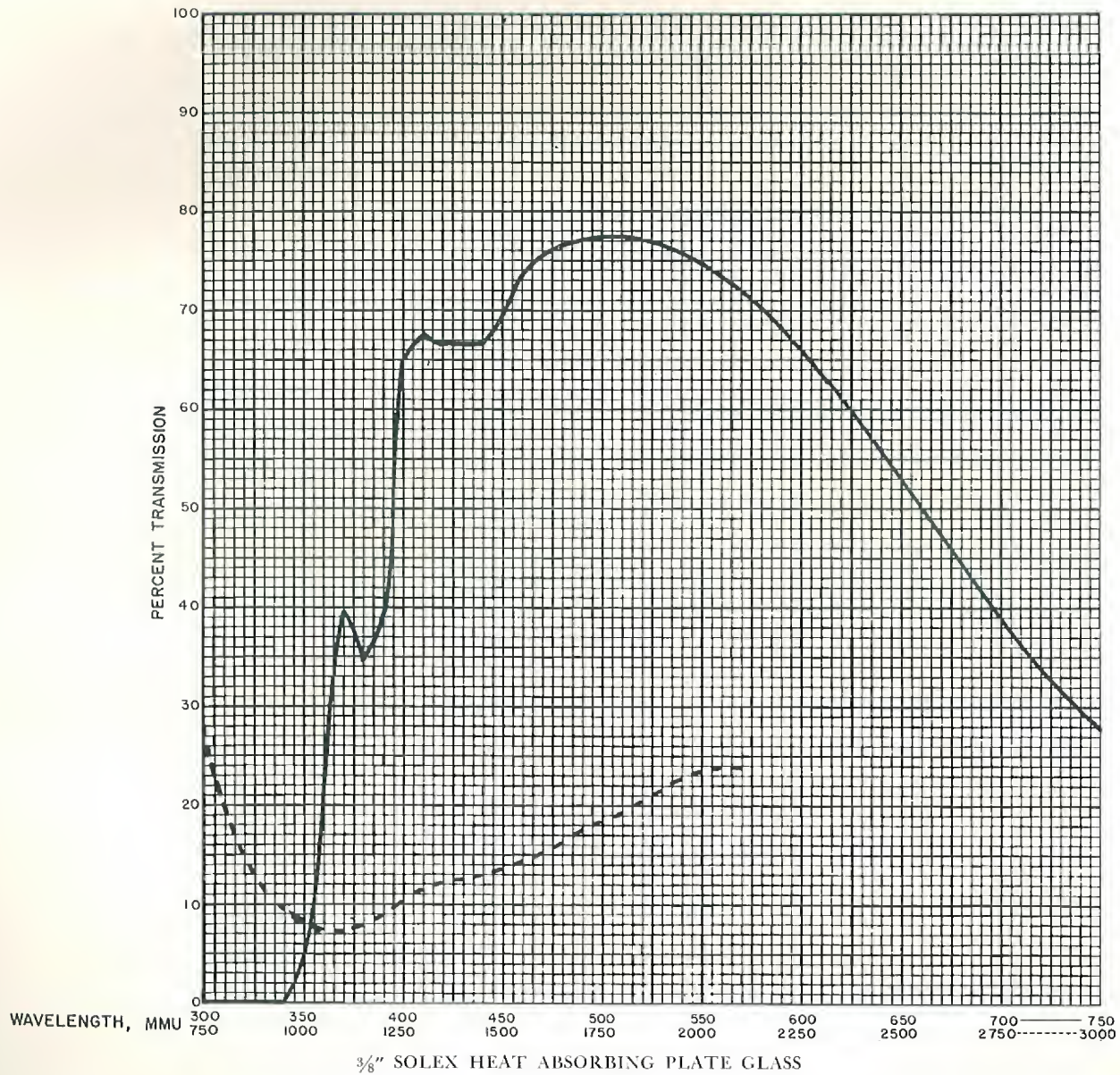
Wave-length MMU	Per cent Transmission
400	64.6
420	66.3
440	66.6
460	73.2
480	76.2
500	77.4
520	77.4
540	76.2
560	73.7
580	70.7
600	65.8
620	61.6
640	55.4
660	50.1
680	44.9
700	38.9
720	33.9
740	29.8
750	27.6

INFRA-RED

Wave-length MMU	Per cent Transmission
800	19.5
900	11.3
1000	8.0
1100	7.2
1200	8.5
1300	11.3
1400	12.4
1500	13.6
1600	15.0
1700	17.6
1800	19.2
1900	21.6
2000	23.5
2100	23.9

Thickness of sample..... .381"
Average
Total solar light.....68.8-75.4%
Total solar energy (calculated) 36.3-44.6%
Total solar ultra-violet.....24.7-33.9%
Total solar infra-red.....10.8-19.4%

SPECTRAL TRANSMISSION

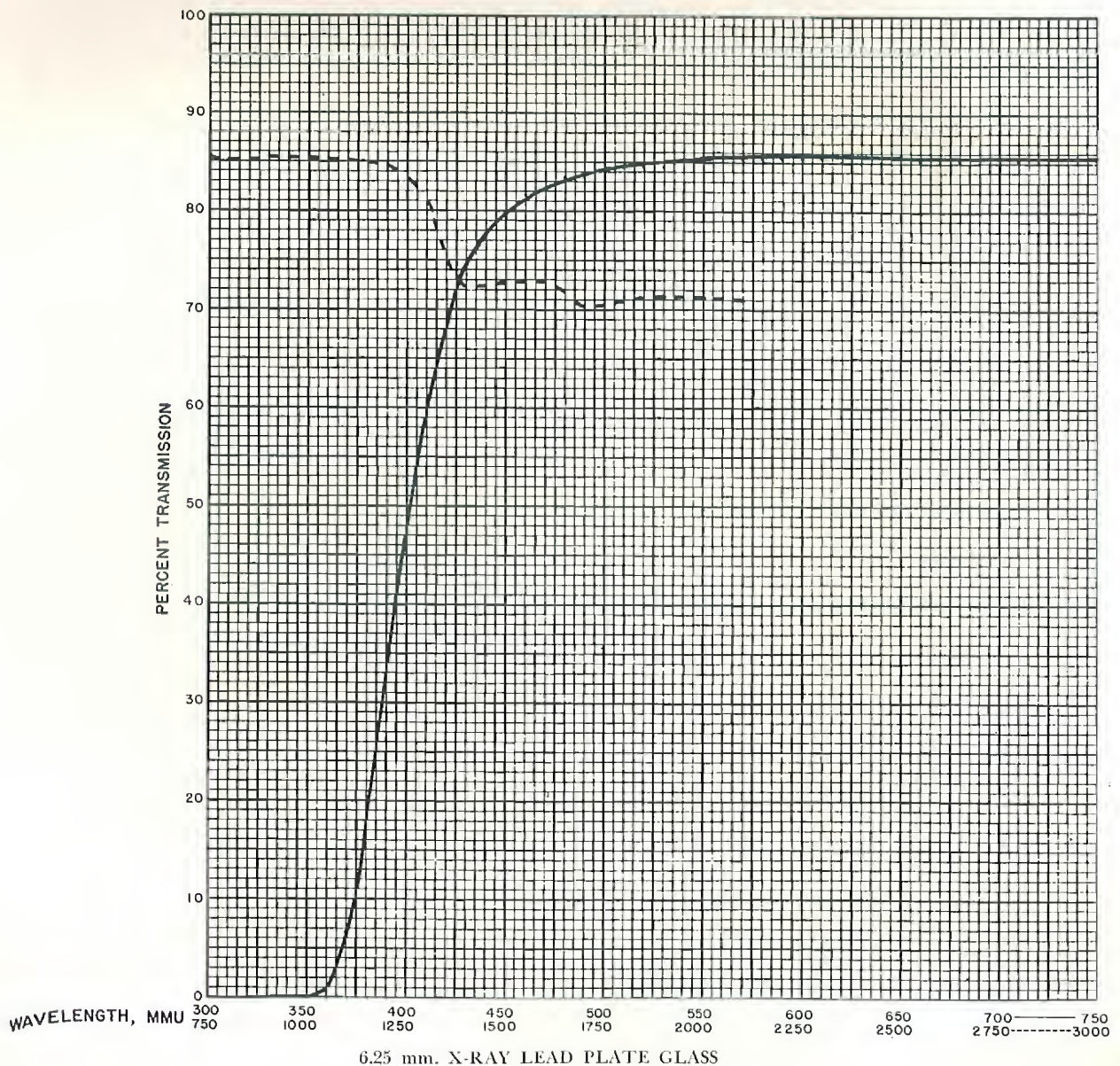


RADIANT ENERGY TRANSMISSION

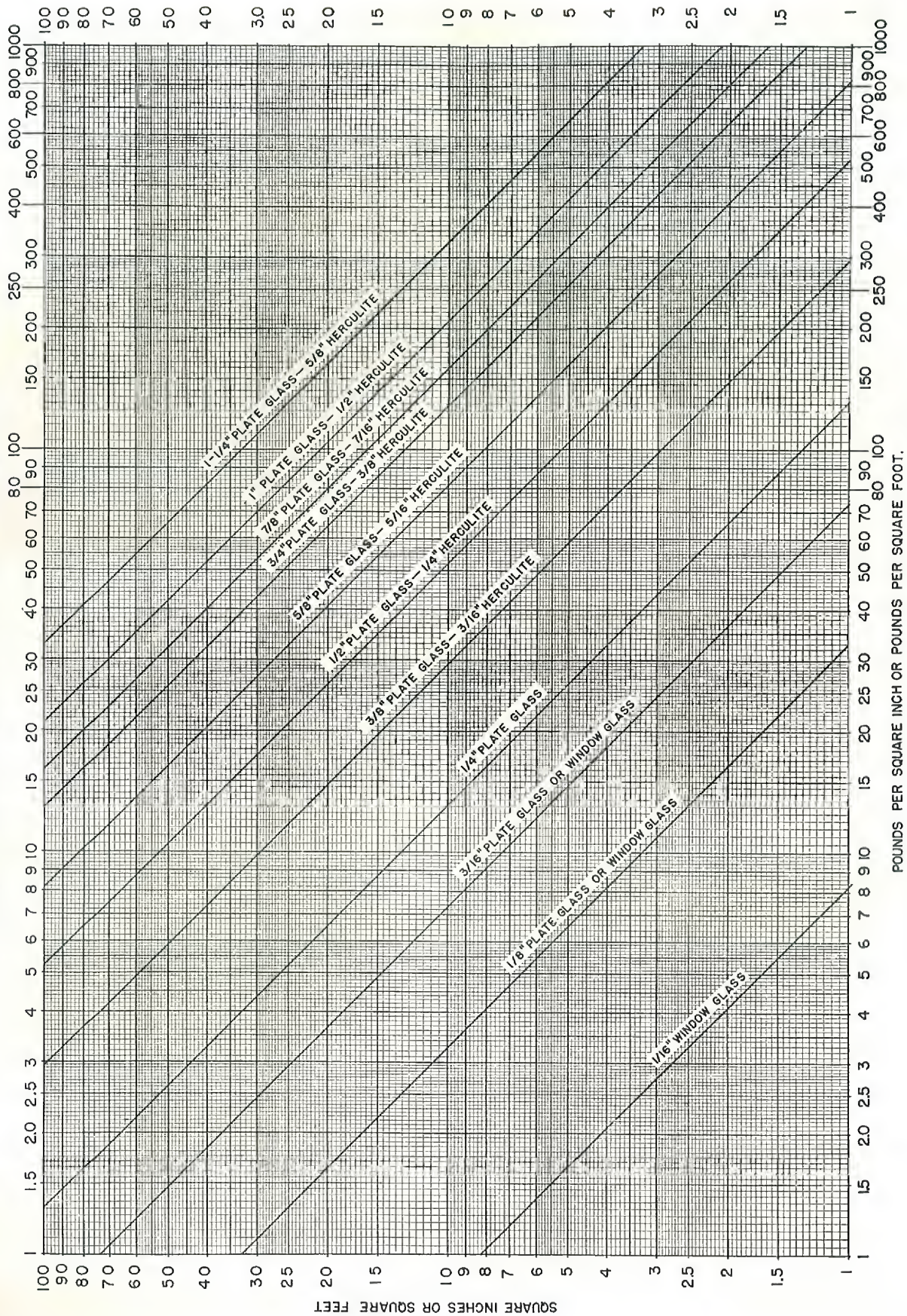
ULTRA-VIOLET		VISIBLE		INFRA-RED	
Wave-length MMU	Per cent Transmission	Wave-length MMU	Per cent Transmission	Wave-length MMU	Per cent Transmission
300	0.0	400	47.4	800	85.2
310	0.0	420	67.5	900	85.5
320	0.0	440	77.5	1000	85.4
330	0.0	460	81.7	1100	85.1
340	0.0	480	83.4	1200	84.7
350	0.0	500	84.0	1300	81.0
360	0.8	520	84.5	1400	72.2
370	6.7	540	85.1	1500	72.7
380	18.7	560	85.5	1600	72.8
390	32.4	580	85.3	1700	70.3
		600	85.4	1800	71.0
		620	85.0	1900	71.2
		640	85.1	2000	71.2
		660	85.2	2100	70.0
		680	85.1		
		700	85.4		
		720	85.5		
		740	85.6		
		750	85.5		

Thickness of sample..... .252" or 6.65 mm.
 Average
 Total solar light.....84.9%
 Total solar energy (calculated).....81.5%
 Total solar ultra-violet.....12.1%
 Total solar infra-red.....82.6%

SPECTRAL TRANSMISSION



SAFE LOADS FOR PLATE GLASS AND WINDOW GLASS



SAFE LOADS FOR HERCULITE, FOUR TIMES THOSE FOR PLATE GLASS OF SAME AREA AND THICKNESS.

SAFE LOADS for

Square Plates of Plate Glass, Window Glass, Laminated Safety Glass or Herculite may be determined from the chart on opposite page.

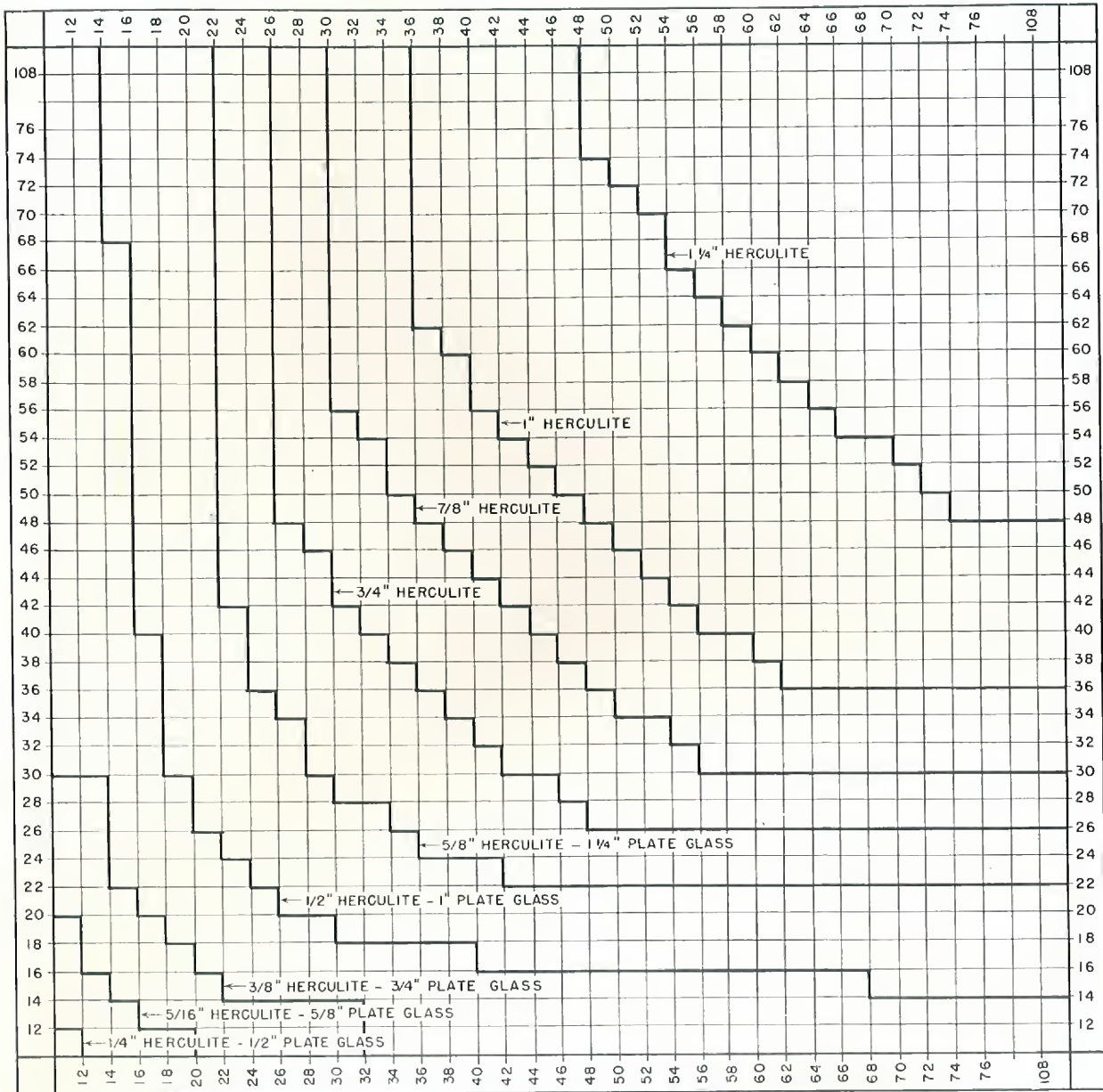
If the area is taken in square inches, the pressure is read in pounds per square inch (psi) and conversely.

If the area is taken in square feet, the pressure is read in pounds per square foot and conversely.

For RECTANGULAR plates of a given area, determine the safe load for a square plate of the same area and multiply the load thus found by the factor shown here for the approximate ratio of short and long dimensions of the plate.

Short Side Long Side	Factor
1.0	1.00
.9	1.005
.8	1.02
.7	1.07
.6	1.11
.5	1.25
.4	1.45
.3	1.80
.2	2.60
.1	5.00

For CIRCULAR plates, determine the safe load for a square plate of the same area and multiply by the factor .897.



Safe glass thicknesses and sizes recommended for use in glass floors based upon 500 lbs. per sq. ft. live load. The lines on the chart show the maximum limits of glass sizes of the thickness indicated, reading from "thickness line" to left.

Carrara Glass

Available in the following colors in thicknesses ranging from $11\frac{1}{32}$ " to $1\frac{1}{4}$ " and in plate sizes up to 72" long by 130" wide.

Black (also $\frac{1}{4}$ "	Ivory	Beige ($11\frac{1}{32}$ " only)
White	Gray	Tranquil Green ^a
Forest Green ($11\frac{1}{32}$ " only)	Orange ($11\frac{1}{32}$ " only)	
Wine ($11\frac{1}{32}$ " only)	Rembrandt Blue ($11\frac{1}{32}$ " only)	

^aExcept $\frac{3}{4}$ "

PROPERTIES:

CARRARA GLASSES—EXCEPT BLACK

Tensile (determined as Modulus of Rupture)	
ultimate.....	6,500 lbs./sq. in. of cross section
Modulus of elasticity.....	10,000,000 lbs./sq. in.
Hardness (Moh's scale).....	6
Solubility (boiling one hour, distilled water, 60 mesh sample)	
Total solids.....	0.068
Total alkali.....	0.011
Specific gravity 70°F.	2.430
Softening point.....	1280°F.—1348°F.
Coefficient of	
linear expansion.....(°C.)	7.78×10^{-6} ; (°F.) 4.32×10^{-6}
Thermal conductivity (K)	
(120°F.).....	8.4158 (B.t.u./sq. ft./hr./in. of thickness/degree F.)
Specific heat (0—100°C., 32—212°F.).....	0.202
Thermal endurance.....	120°F. differential
Total visible white light.....	Essentially zero
Total radiant energy transmission.....	Essentially zero

BLACK CARRARA GLASS

Tensile (determined as Modulus of Rupture)	
ultimate.....	6,500 lbs./sq. in. of cross section
Modulus of elasticity.....	10,000,000 lbs./sq. in.
Hardness (Moh's scale).....	6
Solubility (boiling distilled water)	
Total solids.....	0.174
Total alkali.....	0.042
Specific gravity 70°F.	2.530
Softening point.....	1342°F.
Coefficient of	
linear expansion.....(°C.)	8.2×10^{-6} ; (°F.) 4.55×10^{-6}
Thermal conductivity (K)	
(120°F.).....	7.52 (B.t.u./sq. ft./hr./in. of thickness/degree F.)
Specific heat (0—100°C., 32—212°F.).....	0.207
Thermal endurance.....	130°F. differential
Light transmission	
Total visible white light.....	Essentially zero
Total solar energy transmission.....	28%
Total solar infra-red transmission.....	58%
Total solar ultra-violet.....	01%

Pennvernon Window Glass

AVAILABILITY

PHYSICAL CHARACTERISTICS

Kind	Qualities	Thickness inches		Number of Lights per inch		Average Wt. in Oz. per Square Ft.	Recommended Maximum Size
		Minimum	Maximum	Minimum	Maximum		
Photo	A, B	.058	.061	15.62	17.21	12.68	
Picture	AA, A, B	.062	.070	12.98	14.49	14.97	36" x 50"
Single Strength	AA, A, B	.087	.095	10.50	11.50	18.92	40" x 50"
Double Strength	AA, A, B	.118	.133	7.50	8.50	26.00	60" x 80"
Greenhouse	Greenhouse	.118	.135	7.50	8.50	26.00	Small Lights
3/16" Heavy Sheet	A, B	.187	.200	5.00	5.35	40.14	50 Sq. Ft.
7/32" Heavy Sheet	A, B	.212	.225	4.44	4.72	45.31	60 Sq. Ft.

Heavy sheet glass is not furnished in widths over 76 inches nor in lengths over 120 inches.

Grading of glass in the respective qualities is in accordance with U. S. Government Specifications DD-G-451. In general, the quality depends upon the amount, size and location of imperfections.

PROPERTIES

The physical, thermal, chemical, and light transmission properties are substantially the same as those listed for polished plate glass.

Glasses in this classification are of essentially the same chemical composition as plate glass. They are melted and refined by practically the same methods; the difference in methods of forming the sheets results in certain properties peculiar to the 2 products.

The sheet glasses are drawn directly, under controlled conditions, from the bath of molten glass, and after suitable annealing are cut into the required sizes. The product is characterized by brilliant fire polished surfaces. It is not ground and polished as in the case of plate glass, and hence, does not possess the substantially optical flatness of surface of that product.

Marked improvements in the process of drawing sheet glass, have, in recent years, produced a sheet with the minimum of wave or surface distortion. The dense fire polished surface commends its consideration for uses where the small amount of wave or surface distortion is not objectionable.

RADIANT ENERGY TRANSMISSION DATA

On the following pages will be found charts and tables showing the spectral transmission of Single Strength, Double Strength and Heavy Sheet 7/32" Pennvernon products. These tables and charts are derived from data prepared in the Research Laboratory of the Pittsburgh Plate Glass Company. The data shown are presented as typical of the Company products and do not in any way constitute guaranteed transmission values. The same symbols are used on all of the charts to indicate ultra-violet, visible or infra-red transmission values. Ultra-violet covers the entire range of radiant energy having a wave length shorter than 400 millimicrons down to the lower limit of solar radiation at 292 millimicrons; visible light comprises radiation of all wave lengths from 400 millimicrons to at least 750 millimicrons while infra-red comprises all radiation from 750 millimicrons to at least 100 microns.

LEGEND FOR CHARTS

- Ultra-violet up to 400 mmm
- Visible beyond 400 mmm
- Infra-red, 750-3000 mmm

RADIANT ENERGY TRANSMISSION

ULTRA-VIOLET		VISIBLE		INFRA-RED	
Wave-length MMU	Per cent Transmission	Wave-length MMU	Per cent Transmission	Wave-length MMU	Per cent Transmission
300	1.7	400	90.5	800	84.0
310	2.2	420	90.1	900	81.6
320	14.2	440	90.3	1000	80.6
330	40.7	460	90.8	1100	79.7
340	65.6	480	90.5	1200	80.3
350	79.7	500	91.1	1300	81.4
360	86.1	520	91.2	1400	81.8
370	88.4	540	90.8	1500	83.7
380	87.0	560	90.8	1600	82.8
390	88.9	580	90.5	1700	84.9
		600	89.9	1800	83.5
		620	89.3	1900	85.4
		640	88.9	2000	85.7
		660	88.5	2100	85.5
		680	87.9		
		700	87.3		
		720	86.5		
		740	85.9		
		750	85.6		

Thickness of sample..... .095"

Average

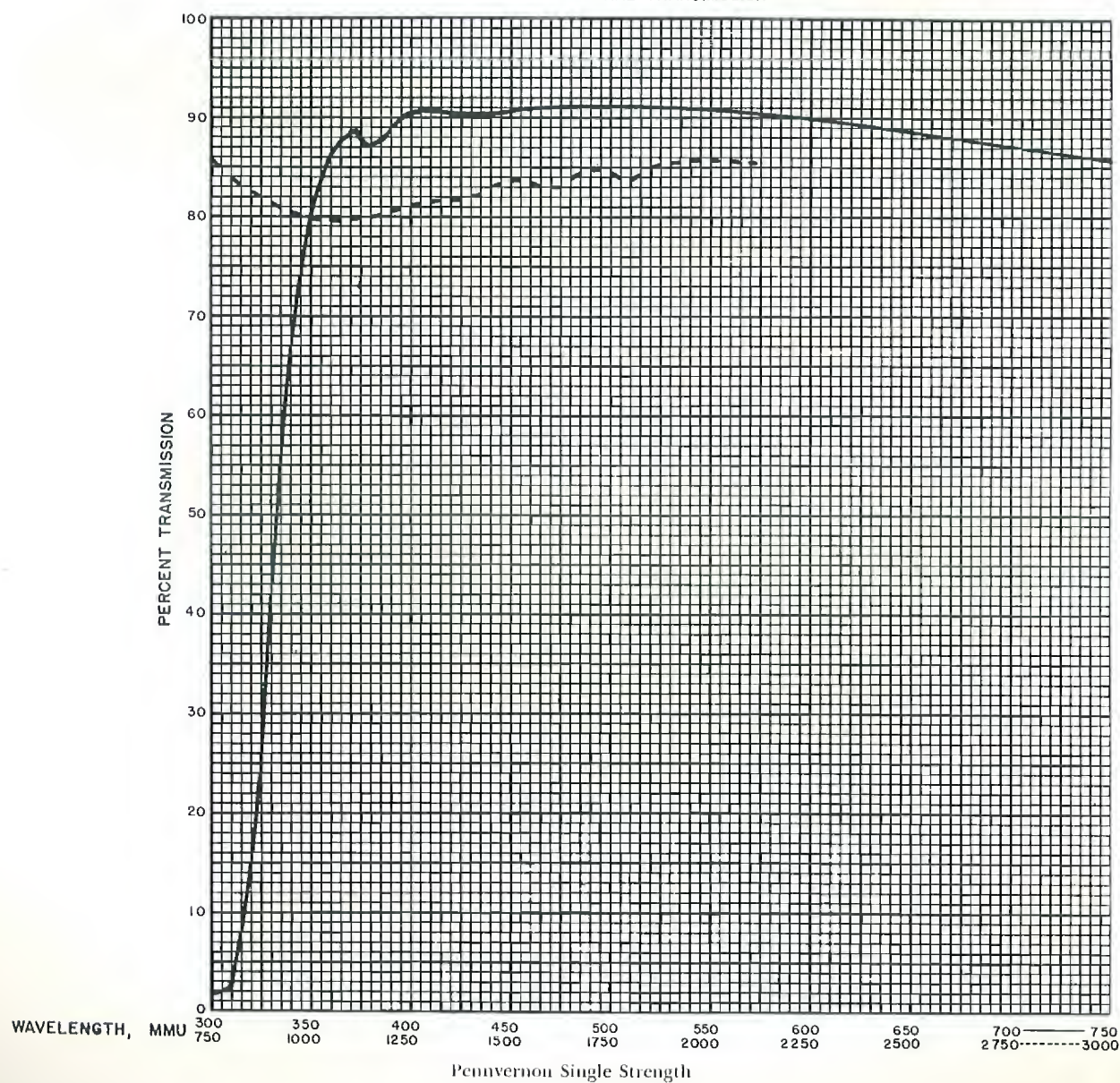
Total solar light.....90.5%

Total solar energy (calculated).....86%

Total solar ultra-violet.....79%

Total solar infra-red.....82%

SPECTRAL TRANSMISSION



RADIANT ENERGY TRANSMISSION

ULTRA-VIOLET		VISIBLE		INFRA-RED	
Wave-length MMU	Per cent Transmission	Wave-length MMU	Per cent Transmission	Wave-length MMU	Per cent Transmission
300	1.4	400	90.2	800	82.0
310	0.6	420	89.5	900	79.3
320	8.9	440	89.8	1000	77.9
330	32.7	460	90.2	1100	77.5
340	59.7	480	90.5	1200	78.3
350	76.5	500	90.5	1300	78.3
360	84.7	520	90.7	1400	80.3
370	87.4	540	91.0	1500	80.5
380	85.5	560	90.3	1600	82.6
390	88.2	580	89.3	1700	82.6
		600	89.1	1800	83.3
		620	89.1	1900	84.1
		640	88.1	2000	84.2
		660	87.4	2100	84.8
		680	86.9		
		700	86.1		
		720	85.4		
		740	84.5		
		750	84.2		

Thickness of sample..... .121"

Average

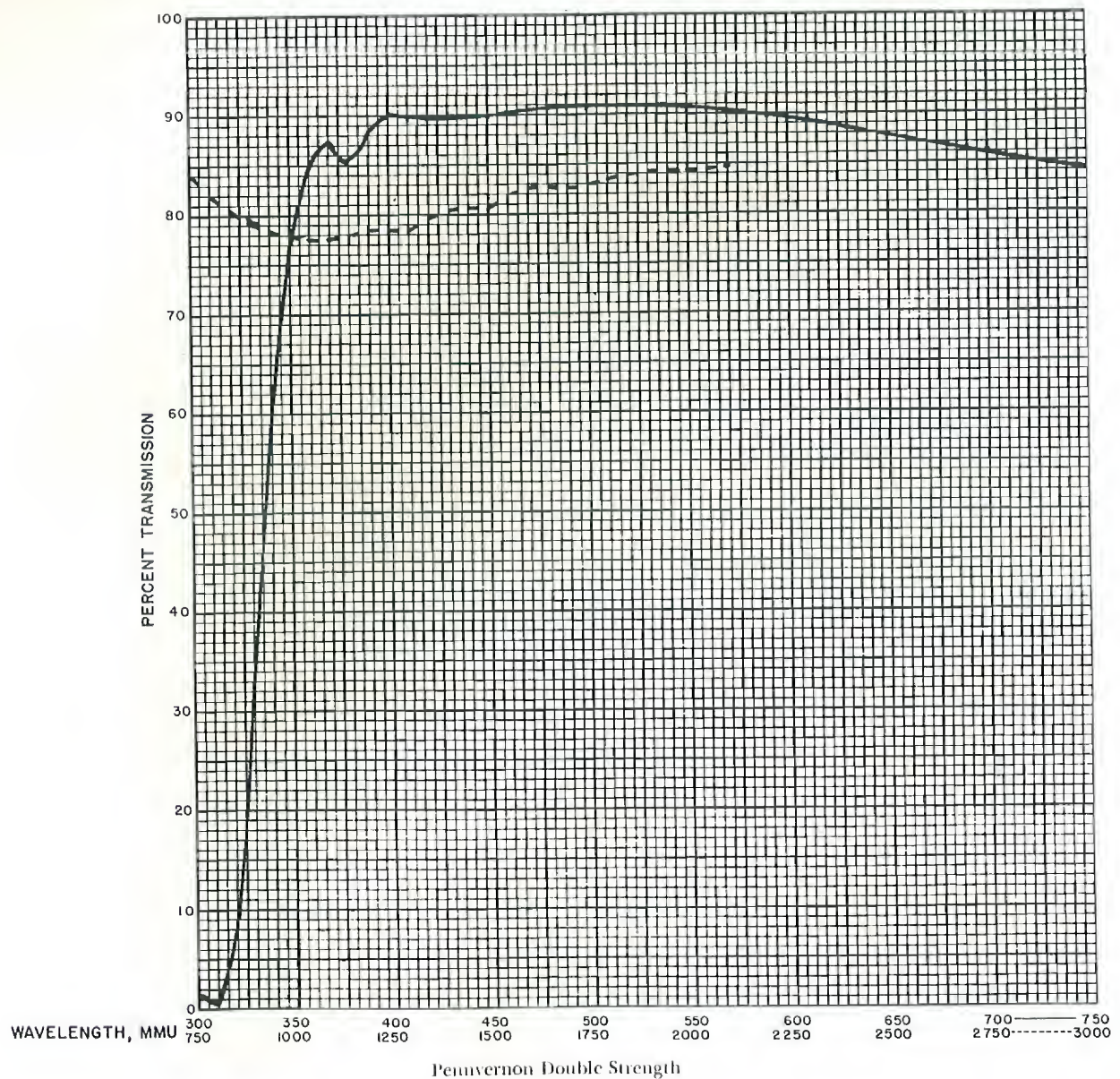
Total solar light.....90%

Total solar energy (calculated).....85%

Total solar ultra-violet.....77%

Total solar infra-red.....70%

SPECTRAL TRANSMISSION



RADIANT ENERGY TRANSMISSION

ULTRA-VIOLET

Wave-length MMU	Per cent Transmission
300	1.3
310	0.3
320	1.2
330	13.7
340	41.3
350	66.0
360	79.5
370	84.4
380	81.2
390	85.3

VISIBLE

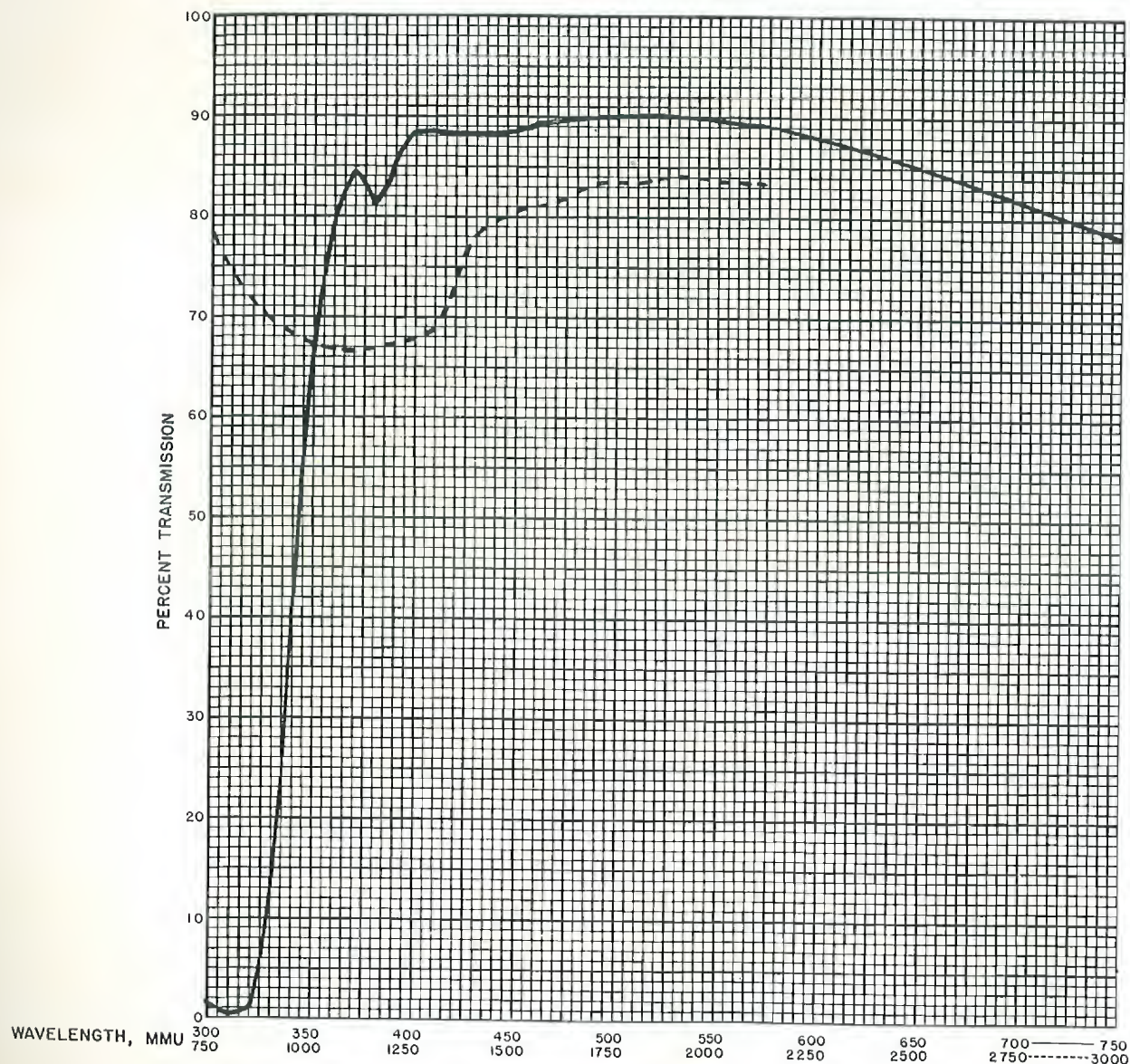
Wave-length MMU	Per cent Transmission
400	88.3
420	88.2
440	88.2
460	89.3
480	89.9
500	90.1
520	90.1
540	89.9
560	89.4
580	88.9
600	87.9
620	86.9
640	85.6
660	84.5
680	83.1
700	81.7
720	80.3
740	78.8
750	78.1

INFRA-RED

Wave-length MMU	Per cent Transmission
800	74.6
900	69.6
1000	67.3
1100	66.6
1200	67.3
1300	68.8
1400	78.1
1500	80.6
1600	81.4
1700	83.3
1800	83.3
1900	84.0
2000	83.7
2100	83.6

Thickness of sample..... 221"
Average
Total solar light..... 89%
Total solar energy (calculated)..... 80%
Total solar ultra-violet..... 70%
Total solar infra-red..... 72%

SPECTRAL TRANSMISSION

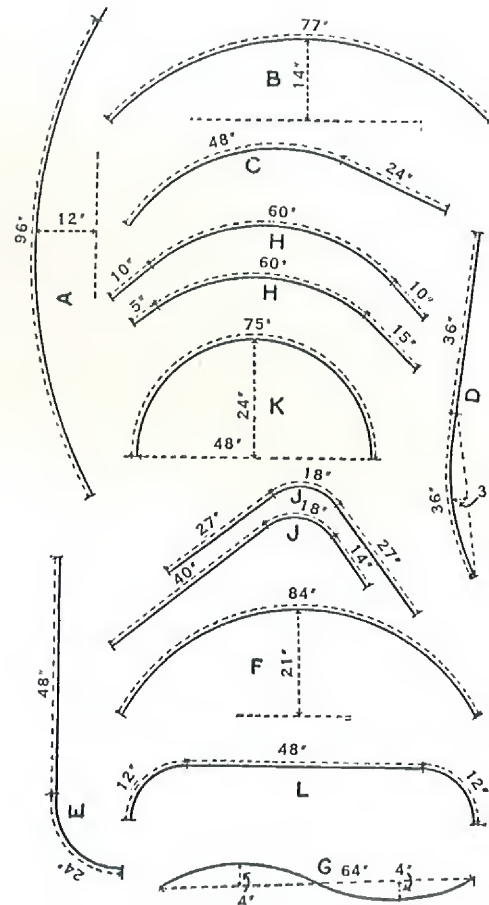


Pennvernon Heavy Sheet $\frac{7}{32}$ "

Bent Glass

EXPLANATION OF CURVES AND DIAGRAMS

- (A) Curves are those which are bent to a given radius one way of the pane only, which applies to the whole length or width of the pane, and not to one part only. The depth of bend not to exceed one-eighth of the length of the bent side of pane. Example, length of the bent side of pane, 96", depth of bend not above 12".
- (B) Curves are those which are bent more than one-eighth but not to exceed the quarter of a circle, or about 1 in 5½. Example, pane 77", bend 14".
- (C) For the same curve as B, but a part flat, the flat part not to exceed one-third. Example, pane 72", bend 48", flat 24".
- (D) For flat curves, with one part flat, the depth of the bent part not to exceed 1 in 12, and the flat part one-half. Example, pane 72", bend 36", depth 3", flat 36".
- (E) For curves, the bent part not less than a 6" radius, and not to exceed the quarter of a circle, with flat part, the flat part to exceed one-third, but not to exceed two-thirds. Example, pane 72", bend 24", flat 48".
- (F) Curves are those which are bent beyond the quarter of the circle, but not to exceed 1 in 4. Example, pane 84", depth 21".
- (G) For OG curves, depth not to exceed 1 in 16. Example, pane 64", depth 4".
- (H) For angular curves, viz.: Flat parts on each side, the centers not to exceed a quarter of a circle, and the flat parts one-fourth of the sides bent. Example, pane 80", bend 60", flat 10" each side, or about 5" one side and 15" the other.
- (J) For angle curves (radius not less than 6"), the center not to exceed the quarter circle, and the flat to exceed one-fourth, but not to exceed three-fourths. Example, pane 72", bend 18", flat 27" each side, or about 14" on one side and 40" on the other.
- (K) Curves are those which are bent beyond 1 in 4 but not to exceed the half circle (diameter not less than 12"). Example, pane 75", depth about 24".
- (L) Curves not to exceed the quarter of a circle



at each side (depth of bend not less than 6"), the bent part not less than one-third, and the flat not more than two-thirds. Example, pane 72", bend 12" each side, center flat 48".

In ordering specify width (measurement around outside of curve) first, and then the height. Specify radius to outside of glass.

It is impossible to keep flat portions of bent glass entirely flat. Where large flat areas are required it is preferable to supply same in separate lights with divisions between bent and flat portion.

Please bear in mind that Bent Glass is made for most part by causing flat glass to conform to a concave mold by the action of heat and gravity only. Although utmost care is used in making the molds and placing the glass, it should be remembered, in judging the accuracy of the bend and freedom from distortion, that bent glass is not a machined product and proper allowances should be made for that fact.

Laminated Safety Glass

Two or more plates of glass with inter-layers of tough transparent plastic are bonded tightly together with the aid of heat and pressure so that even though the laminated plate is broken, practically no part of the glass will fly off and no sharp splinters or cutting edges will be exposed to inflict injuries on persons or materials close by. This type of glass is available in many thicknesses to satisfy the requirements of a multiplicity of uses. Following are described products of the type:

DUPLATE (LAMINATED SAFETY PLATE GLASS)

As the name implies, this consists of 2 pieces of polished plate glass, laminated with an inter-layer of plastic. It affords vision comparable to that of a single piece of homogeneous plate glass. Usual thickness, nominal $\frac{1}{4}$ inch, limits $\frac{7}{32}$ inch to $\frac{9}{32}$ inch. It weighs approximately 3.25 pounds per square foot. It is furnished regularly in sizes up to 48 inches by 84 inches, and under special conditions, by butt-joining the plastic, up to 50 inches by 100 inches.

PROPERTIES:

In most respects those of the homogeneous plate glass from which it is fabricated.

Maximum prolonged temperature exposure.....130°F.
Maximum brief (1 hour or less) temperature exposure....175°F.

Duplate exceeds all requirements of American Standards Association Code for Safety Glass for Automobiles Z-26.1, 1938. This product is universally used in automobile windshields.

DUOLITE (LAMINATED SAFETY SHEET GLASS)

This consists of either 2 pieces of single strength sheet glass or 2 pieces of double strength sheet glass or a combination of single and double strength sheet glass. Duolite produced from single strength glass averages close to $\frac{7}{32}$ inch with a tolerance of $\frac{3}{16}$ inch to $\frac{1}{4}$ inch in thickness, weighs approximately 2.81 pounds per square foot and is produced in sizes up to 45 inches by 84 inches. Duolite produced from double strength glass is furnished in a thickness of from $\frac{13}{64}$ inch to $\frac{19}{64}$ inch and weighs approximately 3.34 pounds per square foot. It also is furnished in sizes up to 45 inches by 84 inches. Duolite produced from combination single and double strength glass is furnished in a thickness of from $\frac{13}{64}$ inch to $\frac{17}{64}$ inch and weighs approximately 3.08 pounds per square foot. It is also manufactured regularly in sizes up to 48 inches by 84 inches, and under special conditions, by butt-joining the plastic, up to 50 inches by 100 inches.

PROPERTIES:

In most respects those of the homogeneous window glass from which it is fabricated.

Maximum prolonged temperature exposure.....130°F.
Maximum brief (1 hour or less) temperature exposure...175°F.

Duolite exceeds all requirements of American Standards Association Code for Safety Glass for Automobiles Z-26.1, 1938.

AEROLITE (LAMINATED SAFETY SHEET GLASS)

This product is produced from 2 pieces of photo or picture glass, averages slightly over $\frac{1}{8}$ inch with a thickness tolerance of $\frac{1}{8}$ inch to $\frac{5}{32}$ inch and weighs approximately 1.62 pounds per square foot. It is made in sizes up to 32 inches by 42 inches.

PROPERTIES:

In most respects those of the homogeneous glass from which it is fabricated.

Maximum prolonged temperature exposure.....130°F.
Maximum brief (1 hour or less) temperature exposure....175°F.

BENT LAMINATED SAFETY GLASS

Duplate, Duolite and Aerolite can be made to practically all the standard bends. However, bent laminated safety glass requires greater tolerances than homogeneous glass, in various dimensions. The glass must be bent before lamination, usually in pairs, and this adds materially to the difficulties of lamination.

Specific inquiry should be made covering special applications contemplated.

MULTIPLATE BULLET-RESISTING PLATE GLASS

Available in plates up to 45 inch by 84 inch maximum in standard thicknesses of $\frac{1}{2}$ inch, $\frac{3}{4}$ inch, $\frac{7}{8}$ inch, 1 inch, $1\frac{1}{8}$ inch Super Multiplate, $1\frac{1}{2}$ inch Hi-Resist Multiplate, and 2 inch Hi-Power Multiplate. Other thicknesses can be supplied on special order.

This glass is a laminated plate glass developed by the Pittsburgh Plate Glass Company for use where special protection is required, usually protection against firearms.

PROTECTIVE QUALITIES OF VARIOUS THICKNESSES

$1\frac{1}{8}$ inch Multiplate, called Super Multiplate and the thickness most commonly used, is satisfactory to resist projectiles developing not more than 490 foot-pounds energy. It will withstand from 4 to 10 shots fired at point blank range from the common sidearms, including the .45 caliber revolver, and the .38 Super Automatic. $1\frac{1}{2}$ inch Hi-Resist Multiplate is satisfactory for use against weapons developing not more than 804 foot-pounds energy. It is especially designed to offer protection against the revolver popularly called the Smith and Wesson Magnum Revolver, shooting a special .357 Magnum cartridge. 2 inch Hi-Power Multiplate is satisfactory for weapons developing not more than 2,400 foot-pounds energy. It is the only glass officially listed for protection against high-powered rifle bullets. It will

withstand successfully several shots from a standard 30-30 sheriff's weapon, and will even turn back a single steel-jacketed service bullet shot from the powerful 30-06 Army Springfield. It also is recommended as adequate protection against a burst of fire from the Thompson Sub-Machine Gun.

PROPERTIES:

Similar to those of the homogeneous glass from which it is fabricated, but varying with structural composition. Specific inquiry should be made covering special applications contemplated.

FLEXSEAL (LAMINATED SAFETY PLATE GLASS)

Flat in plates up to 40" long by 80" wide glass dimensions. Bent in plates up to 40" long by 80" wide projected area. Multiglazed units in sizes up to 20" long by 40" wide.

Flexseal may be considered as a laminated safety glass, similar to safety glass used in automobiles, except that the plastic sandwiched between 2 lights of glass has been purposely made larger than the glass itself so that a plastic rim extends beyond the glass edges after the glass and plastic have been bonded together. This plastic rim may be built to any desired thickness and machined to any desired contour.

Flexseal contains a much thicker and tougher plastic than ordinary safety glass, and this plastic rim becomes the part of the unit which is clamped into the channel or frame, rather than the glass edges. The requirements of the specific installation determine the combination of glass and plastic necessary.

For installations which are not subjected to internal or external pressure, either constant or intermittent, Flexseal may be made of regular polished plate glass. However, for

installations which are subjected to internal or external pressures, either constant or intermittent, it is recommended that the glass used in Flexseal be semi-tempered or fully tempered polished plate glass. The superior properties of tempered glass have been pointed out under the Herculite section.

Experience has shown that the problems presented in glazing ordinary safety glass in airplanes are eliminated or reduced in importance when the glass is glazed as a Flexseal unit which has a tough, flexible plastic rim to be clamped into the frame and bear the brunt of any strains that may arise. The pliable and somewhat compressible plastic edge of Flexseal permits of a tight frame mounting which prevents air leakage. And, even though the glass portion of Flexseal should crack during stratosphere flight, the plastic continues to serve as an airtight diaphragm, preventing loss of cabin pressure.

Bent Glass Flexseal—This type can be manufactured within the commercial bending limits of the glass itself provided the projected area does not exceed 40 inches by 80 inches. Where streamlining and greater field of view are required, the Bent Flexseal is in demand.





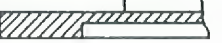






Multi-Glazed Flexseal—To reduce as much as possible the transfer of heat and still retain full vision units made up of 2 or more plates with one or more air spaces between are offered.

Although primarily developed for the glazing of aircraft, Flexseal has characteristics and advantages which recommend its use for many other applications also.

PROPERTIES:

Similar to those of the homogeneous glass from which it is fabricated, but varying with structural composition. Specific inquiry should be made covering special applications contemplated.

Maximum prolonged temperature exposure.....130°F.
Maximum brief (1 hour or less) temperature exposure.....175°F.

CROSS SECTION ILLUSTRATING TYPES OF EXTENDED PLASTIC EDGES				
REGULAR EDGE	FLUSH EDGE	OFF SET EDGE	GLASS 	PLASTIC 
			2 Ply $\frac{7}{64}$ "	1 Ply .060 to .180"
			3 Ply $\frac{7}{64}$ "	2 Ply .120"
			2 Ply $\frac{1}{4}$ "	1 Ply .180"

Mirrors

ANY of the many available transparent glasses may be prepared as silvered mirrors, even in the very largest sizes. However, copper-backed mirrors and structural mirrors are limited to a maximum size of 86 inches long by 168 inches wide.

The methods of production of silvered mirrors, and evaporated mirrors, have been described in Section C-4 and need not be again described here. Transparent or one-way vision mirrors and front surface mirrors are not guaranteed against deterioration, nor for any definite time.

The density of film on transparent mirrors may be exactly controlled so that there shall be a definite amount of visible light transmission and correspondingly a definite amount of visible light reflection, which may or may not be guaranteed.

All mirrors manufactured by the Pittsburgh Plate Glass Company are produced in accordance with the requirements of Commercial Standard CS 27-36 for Mirrors, which has been approved by the United States Department of Commerce in co-operation with representatives of the mirror manufacturing industry. The essential parts of this Commercial Standard are covered in the following paragraphs.

PURPOSE

1. This standard of quality is established as a basis of common understanding for the industry and to assist commercial users of mirrors and ultimate mirror purchasers to distinguish between the various qualities offered for sale. By adoption of this standard it is hoped that interest may be increased in the use of higher quality mirrors, and that shipping costs, packing charges, and other expenses incident to exchange merchandise, which occur through misunderstanding between buyer and seller, may be eliminated.

SCOPE

2. This commercial standard includes plate glass mirrors made from polished plate glass, as well as so-called "shock" mirrors 6 by 8 inches and larger, made from common window glass, which have previously been known as common glass, sheet glass, crystal, or shock mirrors.

USES

3. Because of their high polish, flatness, and uniform thickness, plate glass mirrors produce a true reflection of the objects before them and should, therefore, be used where true and undistorted reflection is essential or desired.

4. Window glass is not ground and polished and has a characteristic surface waviness which presents distortions that are accentuated when the glass is silvered, thus preventing a true reflection of the objects viewed in such mirrors. Window glass, accordingly, finds its chief use in mirrors of relatively small size.

GENERAL REQUIREMENTS

5. All mirrors sold as of commercial standard quality shall be serviceable mirrors equaling or exceeding the quality designated for each grade.

6. Since the central area of the mirror comes in the direct line of vision, it is of greater importance and, therefore, defects occurring therein are more serious than those appearing in the outer area.

7. On mirrors to be fitted into frames, small chips on the edge shall not be considered as defects provided they are at least one-eighth inch smaller than the width of the frame rabbet.

DETAIL REQUIREMENTS

Plate Glass Mirrors

8. Plate glass mirrors are of three distinct grades designated as "A," No. 1, and No. 2, based on the presence of certain defects which generally follow existing grades of plate glass, which are known respectively as silvering, mirror glazing, and glazing qualities. No. 1 and No. 2 quality mirrors constitute the bulk of production. The small remaining production constitutes the finest product of the industry, known as "A" quality, a special classification for the most discriminating trade.

9. The several grades designated below shall comply with the requirements specified. For description of terms see glossary and for the method of inspection see Page 2 of this section.

"A" Quality—The central area of mirrors of this quality shall be free from major defects, but may contain well scattered fine seed and short, faint hair lines, when not grouped, and occasionally very light short finish visible only on close inspection. The outer area, in addition, may contain seed and short, faint scratches when not grouped.

No. 1 Quality—The central area of mirrors of this quality may contain scattered seed, faint hair lines, and light, short finish. The outer area, in addition, may contain short scratches and occasional strings not over 2 inches long.

No. 2 Quality—Mirrors of this quality may contain the following defects: Numerous scattered seed, occasional coarse seed, light reams, strings, light scratches, short finish if not torn, hair lines if not too densely grouped, and bull's eye if not visible from front inspection.

SHOCK MIRRORS

10. Shock or common window glass mirrors are manufactured in one quality only, based upon defects found in win-

dow glass. They are available in single strength and double strength, but are sometimes made of window glass of greater thickness than double strength. Shock mirrors are made of common window glass known in the trade as A quality, the lower grades being unsatisfactory for silvering purposes.

11. The defects permitted in shock or common window glass mirrors are faint strings or lines, slight burns, small seeds, small blisters, and light scratches. No mirror shall contain all of these defects, and those present may not be grouped when in the central area of the mirror. Strings, lines, or burn specks shall not be of such intensity that they are visible when observing the mirror at an angle greater than 30 degrees between the line of sight and the glass. Waves shall not be visible at an angle greater than 20 degrees with the glass. Blisters shall not exceed one-quarter inch in length, unless they occur near the edge of the mirror. In general, the central area of the mirror shall be practically free from defects, and the appearance of the mirror as a whole shall be such that there is no perceptible interference with the reflection of the object as long as one is not looking at the mirror at an acute angle. This standard does not apply to shock mirrors smaller than 6 by 8 inches.

STANDARD THICKNESSES

12. Plate glass mirrors of commercial standard quality shall be between three-sixteenths and five-sixteenths of an inch thick. If specific thicknesses are ordered, a variation of one thirty-second inch plus or minus the given thickness shall be allowed.

13. Shock mirrors of commercial standard quality may be had in three distinct thicknesses, known as single strength, double strength, and heavy, as shown in Table 1.

TABLE 1—THICKNESSES OF SHOCK MIRRORS

Classification	Thickness		Number of lights per inch		Average weight in ounces per square foot
	Minimum	Maximum	Minimum	Maximum	
Single strength ..	Inch 0.087	Inch 0.095	10.50	11.50	18.92
Double strength ..	.118	.133	7.50	8.50	26.00
Heavy (3/16)187	.200	5.00	5.35	40.14

SILVERING

14. All plate glass mirrors of commercial standard quality shall be silvered in an approved manner and guaranteed for a period of one year from the date of manufacture, unless the mirrors are subjected to unusual conditions, such as open weather, moist walls, steamed rooms, direct sunlight, or similar conditions.

15. Shock mirrors are not guaranteed as to silvering.

QUALITY DESIGNATION AND GUARANTEE

16. For the guidance of the buying public, and the protection of the mirror manufacturer, each commercial standard grade mirror may be labeled in the color designated at upper right, with the following statement for each particular grade:

Plate Glass Mirrors

17. Red for "A" quality.
Blue for No. 1 quality.
Green for No. 2 quality.

"We guarantee this mirror to be manufactured of polished plate glass and to be of¹ quality as specified in Commercial Standard CS 27-36, issued by the National Bureau of Standards, U. S. Department of Commerce."

.....
Name of Manufacturer.

¹Indicate whether of "A," No. 1, or No. 2 quality.

Shock Mirrors

18. Yellow.

"We guarantee this mirror to be made of² common window glass in accordance with Commercial Standard CS 27-36, issued by the National Bureau of Standards, U. S. Department of Commerce."

.....
Name of Manufacturer.

²Indicate whether single strength, double strength, or heavy window glass.

METHOD OF INSPECTION

19. It is desirable that a uniform method of inspection be followed since the distance from the mirror being examined, the angle between it and the line of sight, and the intensity of light, all affect the visibility of imperfections.

20. Accordingly, the mirror should be examined in indirect daylight of medium intensity with the inspector's eye on a level with the center of the plate and about 36 inches away.

REFLECTION VALUES

Mirrors are primarily intended for use as reflecting instruments and may be used to reflect invisible portions of the solar spectrum as well as the visible portions with which we see. The invisible reflection may be used in connection with photo electric cells and other similar purposes.

In the accompanying charts are shown typical reflection curves for silver mirrors, gold mirrors and lead sulphide mirrors, both in the visible and invisible portions of the spectrum. These values have been determined by the Electrical Testing Laboratories. They cover the reflection of light incident upon the mirror at 45° to the normal and, therefore, reflected at 90° from the incident beam. The results have been computed from actual measurements.

Measurements in the visible region of the spectrum were made by means of a recording spectrophotometer. This instrument was designed for the measurement of the reflection factors of diffusing

REGULAR COPPER BACK SILVERED MIRROR

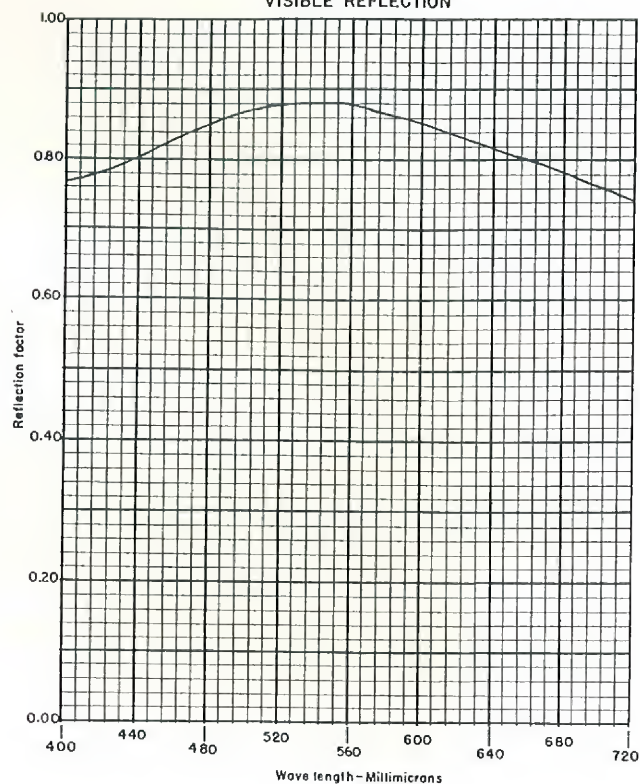
SPECTRAL REFLECTION

Wave Length, mμ	Factor
400	0.76
440	0.80
480	0.85 ₅
520	0.87 ₅
560	0.87 ₅
600	0.85
640	0.81 ₅
680	0.78 ₅
720	0.76

Solar Light Reflection Factor,
45° incidence.....0.86₅

VISIBLE LIGHT _____

SILVER MIRROR VISIBLE REFLECTION



SPECTRAL REFLECTION

Wave Length, mμ		Factor
313	Ultra-Violet	0.05 ₅
334		0.09 ₅
365		0.58 ₅
405		0.76 ₅
800	Infra-Red	0.68
1000		0.60
1200		0.60 ₅
1400		0.68
1600		0.71 ₅
1800		0.75 ₅
2000		0.73 ₅
2200		0.68
2400		0.65 ₅
2600		0.55
2800		0.01

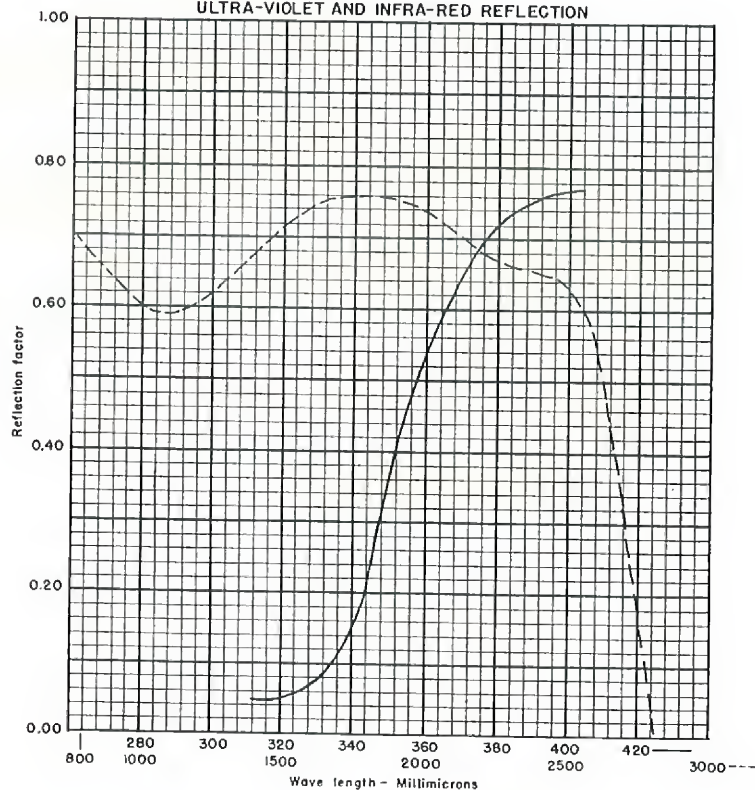
Solar Infra-Red Reflection Factor.....0.88₅
Solar Energy Reflection Factor.....0.74
Thickness.....6.65 mm.

ULTRA-VIOLET _____

INFRA-RED -----

SILVER MIRROR

ULTRA-VIOLET AND INFRA-RED REFLECTION



GOLD MIRROR

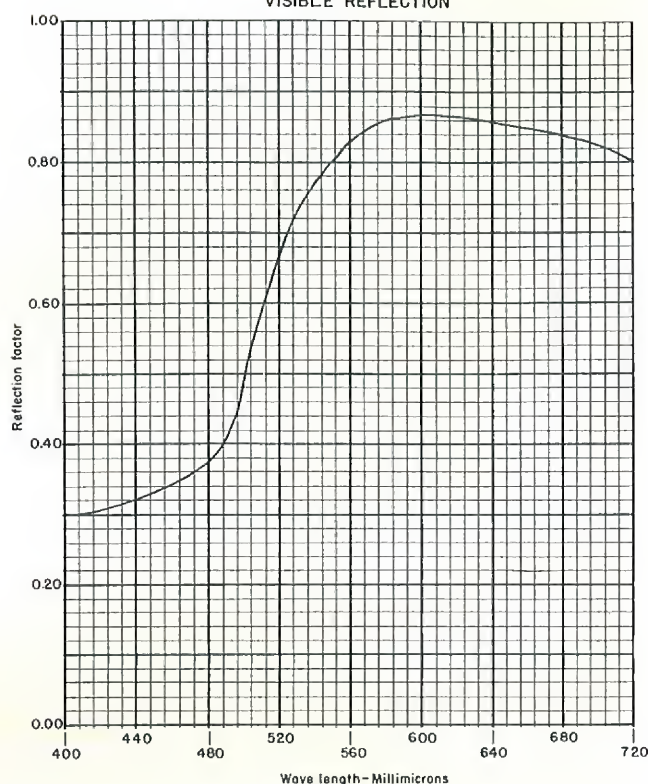
SPECTRAL REFLECTION

Wave Length, mu	Factor
400	0.30
440	0.32
480	0.37
520	0.67
560	0.83 ₅
600	0.86 ₅
640	0.85
680	0.83 ₅
720	0.81

Solar Light Reflection Factor,
45° incidence0.77

VISIBLE LIGHT _____

GOLD MIRROR VISIBLE REFLECTION



SPECTRAL REFLECTION

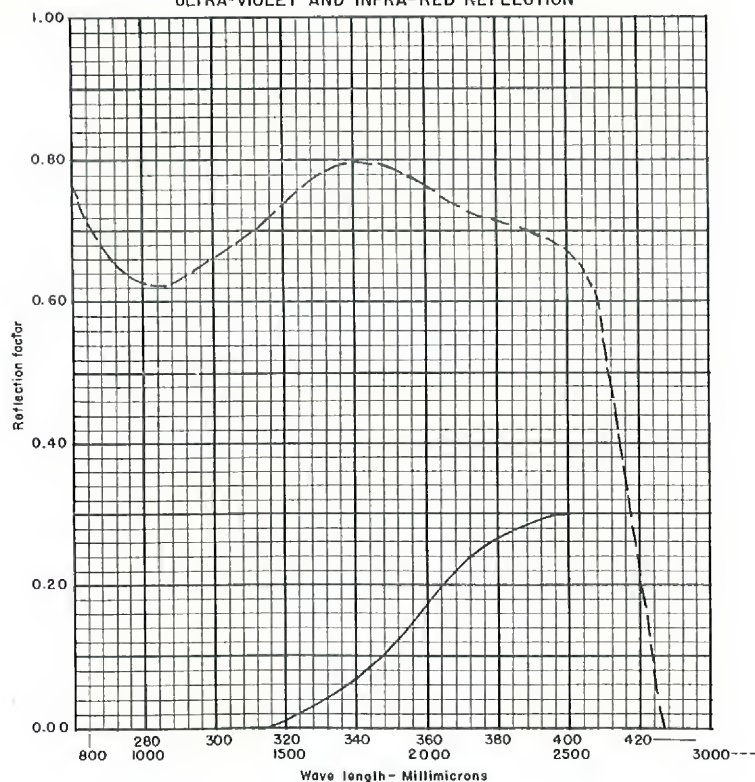
Wave Length, mu		Factor
313	Ultra-Violet	0.00
334		0.06 ₅
365		0.22
405		0.29 ₅
800	Infra-Red	0.71
1000		0.63
1200		0.65
1400		0.70 ₅
1600		0.77 ₅
1800		0.79
2000		0.76 ₅
2200		0.72 ₅
2400		0.69 ₅
2600		0.60 ₅
2800		0.08 ₅

Solar Infra-Red Reflection Factor.....0.68₅
Solar Energy Reflection Factor.....0.66₅
Thickness.....6.35 mm.

ULTRA-VIOLET _____

INFRA-RED - - - - -

GOLD MIRROR ULTRA-VIOLET AND INFRA-RED REFLECTION



GUN METAL MIRROR (LEAD SULPHIDE)

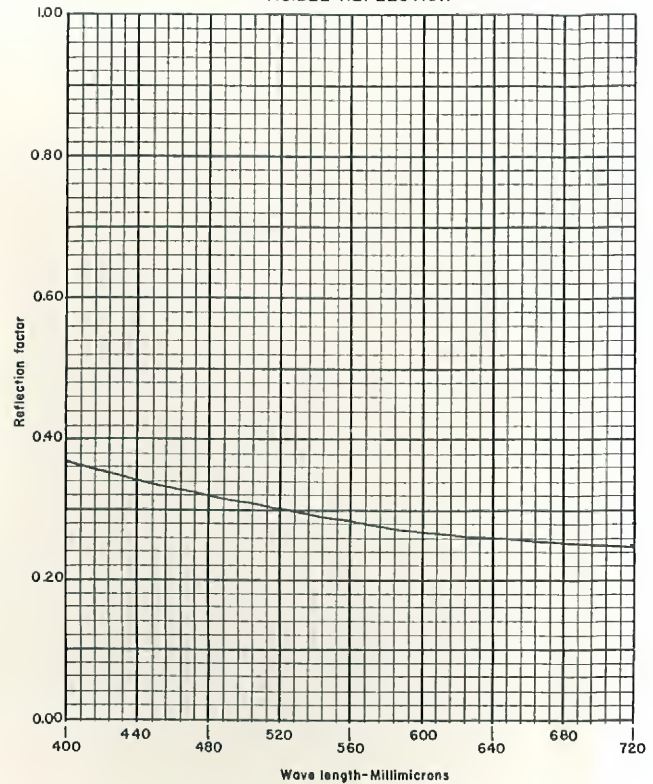
SPECTRAL REFLECTION

Wave Length, mu	Factor
400	0.37
440	0.34
480	0.32
520	0.30 ₅
560	0.29
600	0.27 ₅
640	0.27
680	0.25 ₅
720	0.24 ₅

Solar Light Reflection Factor,
45° incidence.....0.29

VISIBLE LIGHT_____

GUN METAL MIRROR VISIBLE REFLECTION



SPECTRAL REFLECTION

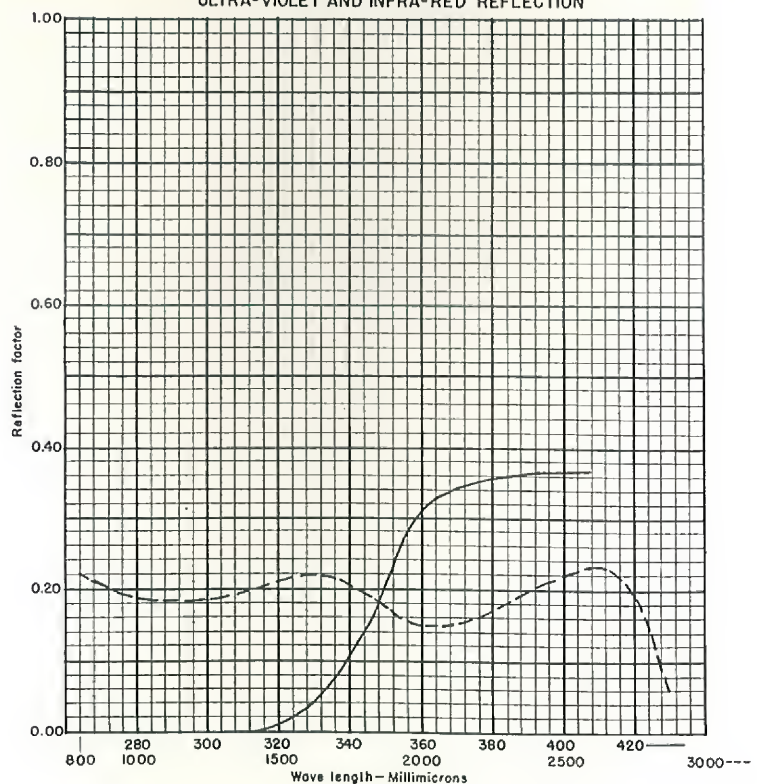
Wave Length, mu		Factor
313	Ultra-Violet	0.00
334		0.00 ₅
365		0.33 ₅
405		0.36 ₅
800	Infra-Red	0.22
1000		0.19
1200		0.18 ₅
1400		0.18 ₅
1600		0.22
1800		0.19 ₅
2000		0.15
2200		0.16
2400		0.21 ₅
2600		0.22 ₅
2800		0.03 ₅

Solar Infra-Red Reflection Factor....0.20
Solar Energy Reflection Factor.....0.25
Thickness.....6.57 mm.

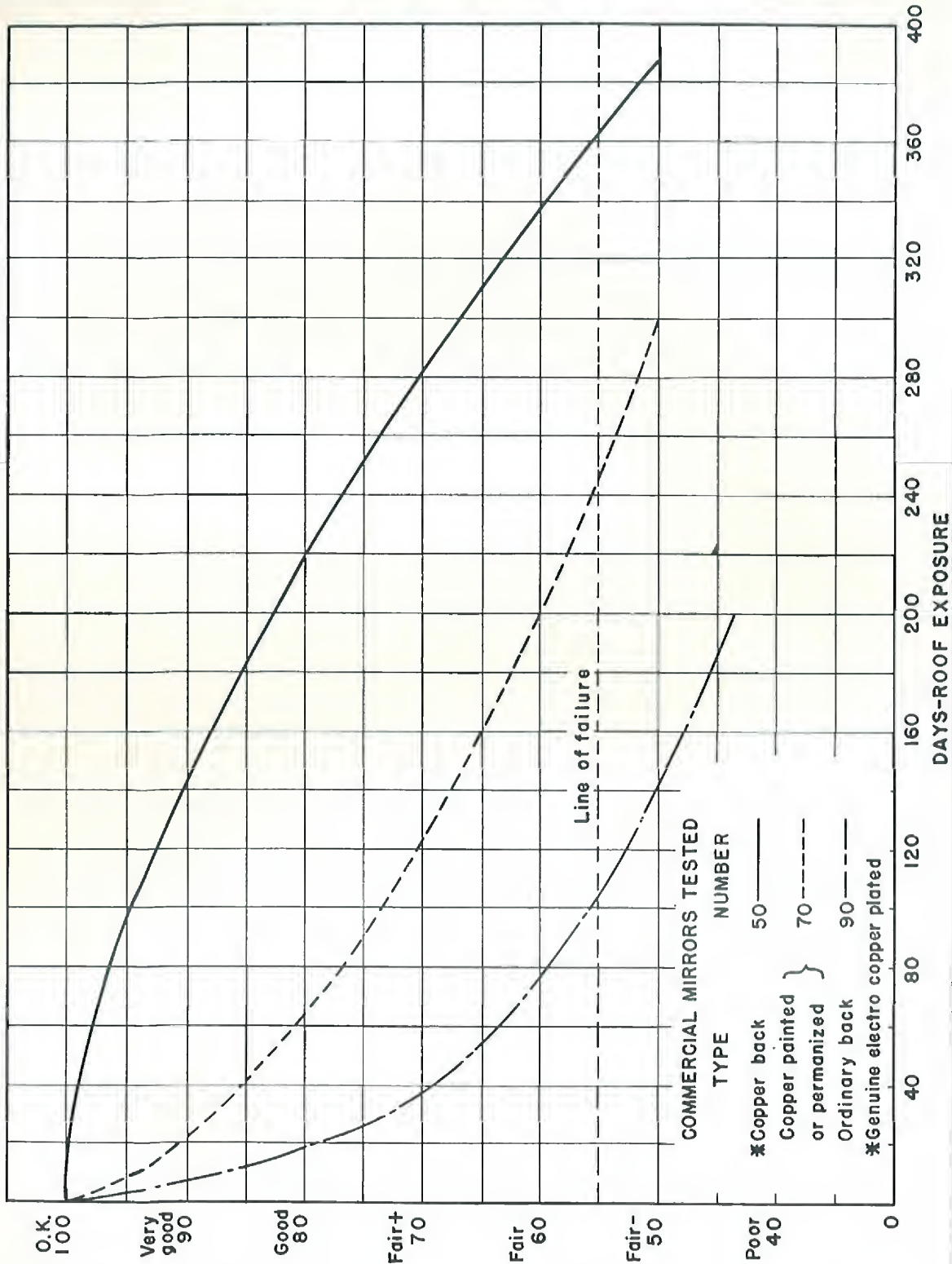
ULTRA-VIOLET_____

INFRA-RED-----

GUN METAL MIRROR ULTRA-VIOLET AND INFRA-RED REFLECTION



EXPOSURE TESTS OF COMPETITIVE COMMERCIAL MIRRORS



Comparative life of mirrors.

surfaces. The incident light falls normally on the mirror surface and a large portion of the specularly reflected light reemerges through the entrance opening. To measure specular samples the specimens must be tilted approximately 3° so that all of the specularly reflected light remains inside the sphere. Reflection curves were drawn for all the samples so positioned and also for a rhodium mirror standardized at the National Bureau of Standards. These results were then corrected for the fact that the light reflected from the standard magnesium oxide block and light reflected from the sample were not symmetrical with respect to the photocell window in the sphere, utilizing the known spectral reflection data for the rhodium mirror. Further computation was then made to give the reflection factors for light incident at 45° in order to place the measurements in the visible portion of the spectrum in correspondence with those for the ultra-violet and infra-red. This was accomplished by computing the path length in the glass for 45° incidence and reflection. The transmissions for this thickness of glass were then computed. The results for the visible region are not

in terms of magnesium oxide due to the fact that the values obtained are determined by a substitution method utilizing the known values for the rhodium mirror.

Infra-red measurements were made by a substitution method. A front surface silver mirror was substituted for the sample being measured. The light was incident at 45° and the reflected beam was directed into the spectrometer. The ratio of the intensity of the light reflected from the standard and from the specimens being investigated was determined and from the known reflection factors for the silvered mirror the true reflection factors for each specimen were computed.

The ultra-violet measurements were made with the same procedure as was utilized for the infra-red, the sole change being that a rhodium mirror was used as a standard instead of the silver mirror. This was done because of the higher reflectivity of rhodium in the ultra-violet which aided in the making of the measurements.

The spectral reflection factors given include both the front surface and back surface reflections of the mirror.

Ceramic Enameled Glass

Available in $\frac{1}{4}$ " thick plates up to 48" long by 84" wide in a variety of colors, opaque or translucent (to varying degrees). Other thicknesses and designs in several colors of enamels also may be produced.

This product is made by spraying a thin uniform coating of powdered glass enamel over one surface and fusing this enamel into the plate at 1150°F. in the Herculite tempering process.

PROPERTIES:

Modulus of rupture, impact resistance, thermal endurance and safe working temperature are the same as Herculite.

Enamel is acid resisting, fitted carefully to the glass to insure no crazing or chipping.

Work on the plates such as grinding edges or drilling must be done before the firing operation.

Standard Colors: green, ivory and black

Sizes: 4" x 4" to 48" x 84" in $\frac{1}{4}$ " thickness

Other thicknesses and colors are special

Nucite is a glass chalkboard made by fusing to the face of polished plate glass a colored vitreous material hardened to resist the abrasion of chalk and eraser. The process which fuses the writing surface of Nucite to the polished plate base gives the finished plate far greater shock resistance than ordinary glass of the same thickness.

Nucite takes a chalk mark easily and yet may be easily and cleanly erased. The armored surface is practically indestructible and will not become shiny and slick with use—which means that the original nonglare quality of the surface is retained through the years.

Being nonabsorbent and unaffected by water and common solvents, Nucite can be washed and completely freed of the binder in chalk which so often fills up the pores and crevices of ordinary chalkboards causing unpleasant odors.

The Ivory Nucite and Green Nucite have been designed particularly to minimize glare, to promote better school room lighting, to lessen eyestrain for students and also as a relief from the depressing black color of common black chalkboards, generally used.

Lighting Glasses

CONTROL SAMPLE

BARE LAMP

1" LAMP TO GLASS

2" LAMP TO GLASS

4" LAMP TO GLASS



The following glasses may be used flat or in standard or special bent shapes:

ROUGH WATER WHITE—in $\frac{5}{32}$ ", $\frac{3}{16}$ ", and $\frac{21}{64}$ " thicknesses.

A clear nongreenish glass with a surface pattern of very fine diamond texture.

Total light transmitting efficiency 90%.

(Same glass blasted on one face efficiency 85%)

REEDED WATER WHITE—in $\frac{5}{32}$ " thickness in sizes up to 36" long by 72" wide.

A clear nongreenish glass with a surface pattern of flutes $\frac{3}{8}$ " wide in one direction. Both surfaces of the glass are slightly roughened to increase the light dispersing effect and to eliminate specular reflection.

Total light transmitting efficiency 94%.

(Same glass blasted on one face efficiency 87%)

REEDED OPAL—in $\frac{5}{32}$ " thickness in sizes up to 36" long by 72" wide.

A light density, high efficiency, solid opal diffusing glass. Same pattern and surface as reeded water white. More diffusing power than reeded water white blasted, but at the same time more easily cleaned.

Total light transmitting efficiency 83%.

ROUGH OPAL—in $\frac{5}{32}$ " thickness in sizes up to 36" long by 72" wide.

Same glass as the reeded opal, but without the reeded pattern. Surfaces are slightly roughened to eliminate specular reflections.

ROUGH FLESH-TINTED—in $\frac{3}{16}$ " thickness.

A pinkish glass with a surface pattern of very fine diamond texture.

Designed to change the greenish white light of the White fluorescent lamp to a more pleasing warm light particularly for beauty shops, restaurants, and meat shops.

ENAMELED GLASSES

Any of the above glasses, as well as plate glass, window glass, and other glasses may be coated with a fused-on layer of ceramic enamel of almost any density, white or tinted. This process makes available glasses, plain or with rolled pattern, with a cleanable diffusing surface. The application of the enamel in designs offers an effective means of decoration.

COVER PLATES

Herculite tempered and ordinary glass plates, transparent and obscured, are used in industrial fixtures to protect materials in process, to protect workers, to reduce the cleaning problem, to protect the light tube, to reduce the glare on many inspection jobs, and to improve the appearance.

A great number of Herculite Plate Glass discs have been used as cover plates or windows in searchlights and floodlights.

BENT GLASSES

Available in 18 standard shapes bent in lengths up to 50 inches ranging in width for 1 to 6 fluorescent tubes. Other shapes and greater lengths may be manufactured on special order.

REFLECTORS

For concentrating the light from a tube which is useful in high bay and spotlighting—can be furnished as silvered glass parabolic (or other shape) reflectors in lengths up to 50 inches.

MISSISSIPPI FIGURED AND DECORATIVE GLASSES

These well-known rough rolled glasses have been used in quantity in fluorescent lighting fixtures particularly in these patterns: Bandlite, Bevelite, Pentecor, Factrolite, Hylite, Dewlite, and Pluralite, either as rolled or with an obscured surface.

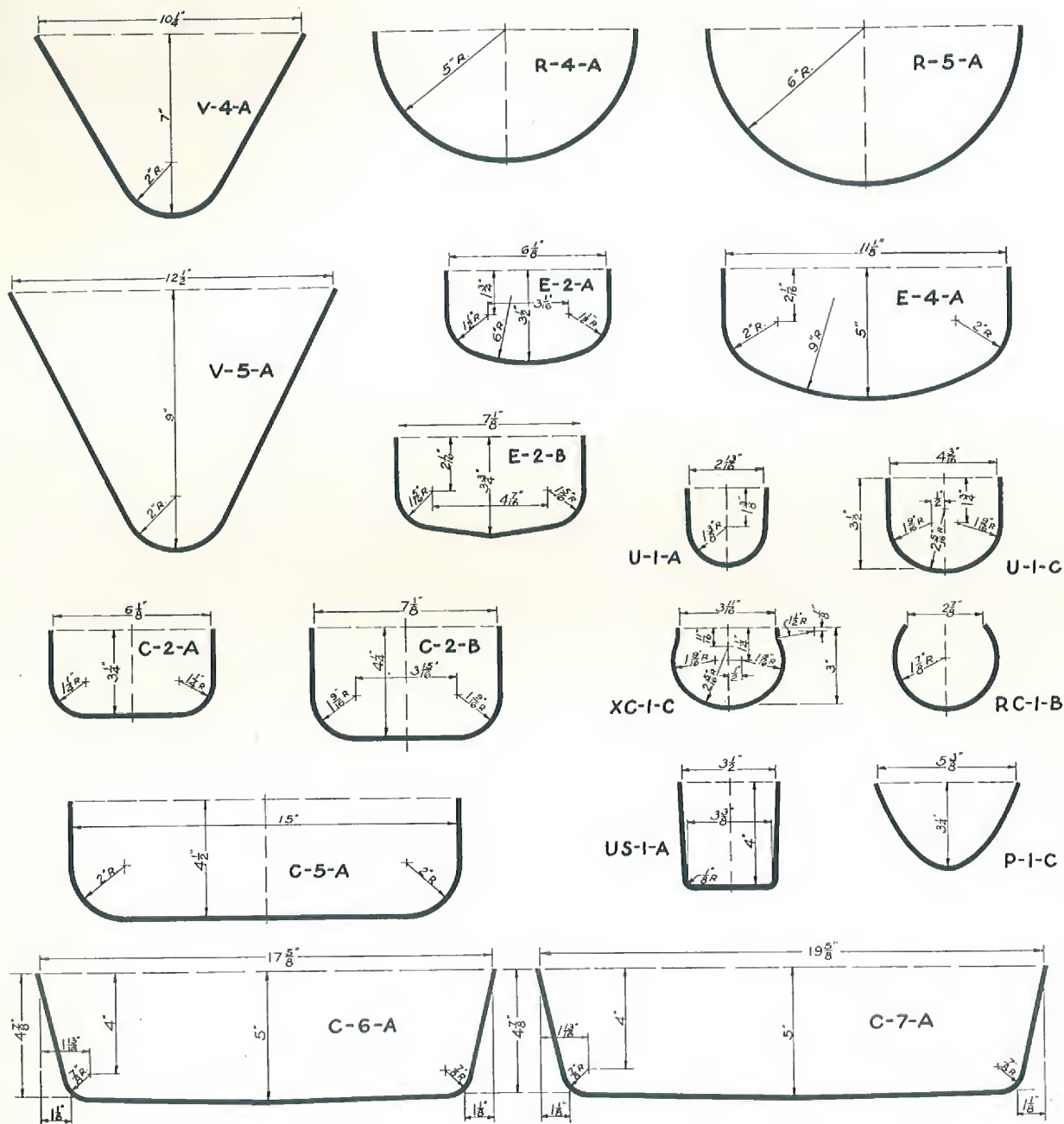
These glasses are available as flat plates and also bent to shape.

TECHNICAL DATA ON FLAT PITTSBURGH LIGHTING GLASSES

NOTE - ALL VALUES WERE DETERMINED BY THE ELECTRICAL TESTING LABORATORIES EXCEPT WHERE MARKED (XXX) BY PITTSBURGH PLATE GLASS COMPANY.

W. O. NO.	NAME	DESCRIPTION	EFFICIENCY % METHOD "AE"	DIFFUSING OR DISPERSING POWER XXX	TRANSMISSION OF LIGHT--%				REFLECTION PERCENT	BRIGHTNESS--PERCENT OF BARE LAMP						SPECULAR REFLECTION OF SURFACE	
					TEST "AT" XXX	TEST "BT" XXX	SPECTRAL			GLASS 1" FROM TUBE			GLASS 3" FROM TUBE				
							RED	GREEN		BLUE	NORMAL			NORMAL			
											ON CENTER "A"	2" OFF CENTER "B"	45° TO NORMAL "C"	ON CENTER "A"	2" OFF CENTER "B"		45° TO NORMAL "C"
FDC-21	Rough crystalex 21/64" thick	Special water clear non-efflorescing glass with fine dotted texture	90		92											Low ₁	
FDC-12	Same except 12/64"	Same	90		92											Low ₁	
FDC-21B	Rough crystalex blasted 21/64"	Same except with one surface sandblasted	84		75											Very low S.B. side ₁	
FDC-12B	Same except 12/64"	Same except with one surface sandblasted	84		75											Very low S.B. side ₁	
FDC-9	Rough water white 9/64" thick	High transmission water clear glass with fine diamond-dot texture	91	0.20	88	71	91.5	91.5	90.5	77	1.7	43	63	1.8	3.4	Low	
FDC-9B	Same except blasted	Same except with one surface sandblasted	85	4.5	71	59				40	4.3	17	30	4.7	1.5	Very low S.B. side	
FDC-9E	Same except enameled	Same except with fired medium opal enamel one surface		4-1	57					29	5.5	20	14	5.9	7.3	Medium enom. side	
FRC-9	Reeded water white 9/64" thick	High transmission water clear glass with flutes 5/8" wide	94	0.1	93	80	91.5	91.5	90.5	82	1.0	53	77	1.2	4.1	Low	
FRC-9B	Same except blasted	Same except with flat surface sandblasted	87	4.1	74	62				47	4.0	32	34	4.5	2.0	Very low S.B. side	
FRC-9E	Same except enameled	Same except with fired medium opal enamel-flat surface		1.5	60					27	5.7	19	14	6.1	8.2	Medium enom. side	
FRO-9	Reeded opal	High efficiency-light density solid opal glass with flutes 5/8" wide	83	12.0	65	63	66	64	60	41	5.0	22	23	4.5	1.1	Low	
FDF-9	Rough flesh tinted 9/64" thick	Rosy tint glass for decorative effects and for food shop and beauty parlor use		0.2	85	69	90	80	82							Low	
FDF-9B	Same except blasted	Same except with one surface sandblasted		4.2	66	62										Very low S.B. side	
FDF-9E	Same except enameled	Same except with fired medium opal enamel one surface		2.7												Medium enom. side	
FPC-16	Herculted polished crystalex 1/4" thick	Tempered transparent water clear glass			88	91	91	91	90	10						High ₂	
FPC-16B	Same except blasted	Same except with one surface sandblasted														Very low S.B. side	
FPC-16E	Same except enameled	Same except with fired medium opal enamel one surface														Medium enom. side ₃	
FPP-14	Herculted polished plate 1/4" or 3/16"	Tempered transparent best quality plate glass														High	
FPP-14B	Same except blasted	Same except with one surface sandblasted														Very low S.B. side	
FPP-14E	Same except enameled	Same except with fired medium opal enamel one surface														Medium enom. side	
FWG-7	Double strength window glass	Best quality window glass		0.0	93	84				10						High	
FWG-7B	Same except blasted	Same except with one surface sandblasted		0.6	75	62				18	5.6	2.4	4.1	3.4	2.7	18	Very low S.B. side
FWG-7E	Same except enameled	Same except with fired medium opal enamel one surface														Medium enom. side	

NOTES: * Determinations made with polished surfaces; ** Glass 2" from tube instead of 1"; 1-Non-specular surface as rolled; 2-Particularly for Protective Plates of Industrial Units;
 3-Enamel colors other than Opal also can be furnished: "AE" "AT" "BT" "A" "B" "C" refer to methods of test illustrated and described in this section. Also described are test methods "BE" and "CE" for determining Efficiency. Care must be exercised in using and comparing efficiency values that have been determined by comparable methods.

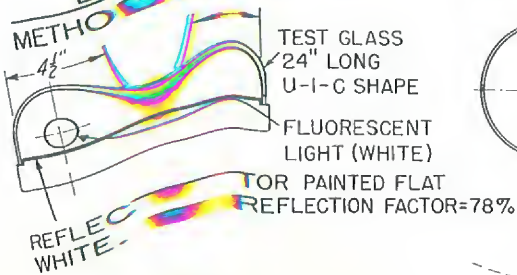


Details of Standard Bent Shapes for Lighting Glasses.

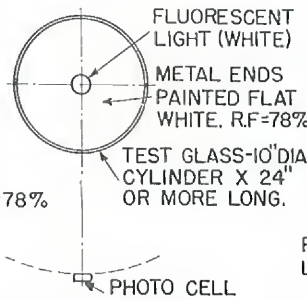
EXPLANATION OF TEST METHODS FOR LIGHTING GLASSES

EFFICIENCY RATING TESTS

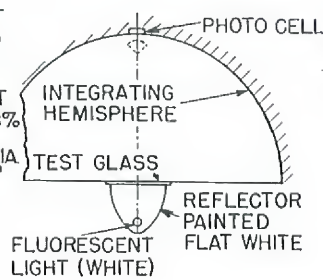
METHOD "AE"



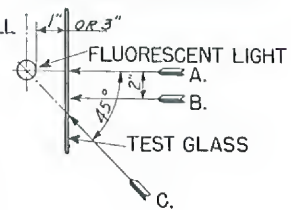
METHOD "BE"



METHOD "CE"



BRIGHTNESS DETERMINATIONS



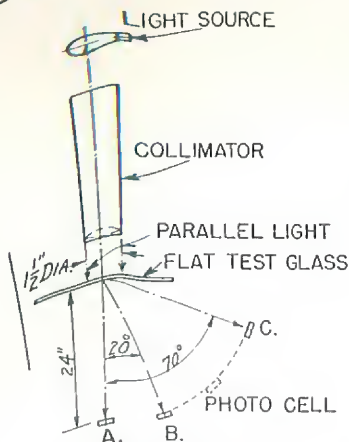
$$\text{EFFICIENCY RATING} = \frac{\text{LIGHT OUTPUT WITH GLASS}}{\text{LIGHT OUTPUT WITHOUT GLASS}}$$

$$\text{EFFICIENCY RATING} = \frac{\text{LIGHT OUTPUT WITH GLASS}}{\text{LIGHT OUTPUT WITHOUT GLASS}}$$

$$\text{EFFICIENCY RATING} = \frac{\text{LIGHT OUTPUT WITH GLASS}}{\text{LIGHT OUTPUT WITHOUT GLASS}}$$

BRIGHTNESS METER
DIRECTED AS SHOWN
BY ARROWS

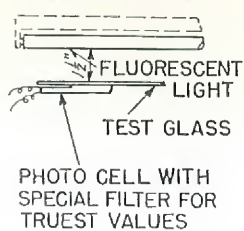
DIFFUSING POWER



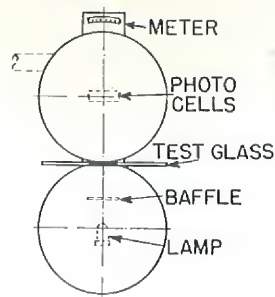
$$\text{DIFFUSING POWER} = \frac{\text{AVE. OF ILLUM. BETWEEN "B-C"}}{\text{ILLUMINATION AT "A"}}$$

LIGHT TRANSMISSION

METHOD "AT"

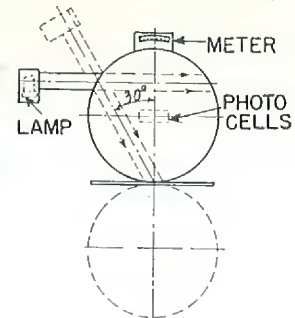


METHOD "BT"



$$\text{LIGHT TRANSMISSION} = \frac{\text{METER READING WITH GLASS}}{\text{METER READING WITHOUT GLASS}}$$

LIGHT REFLECTION



BAUMGARTNER SPHERICAL PHOTOMETER
AS USED BY ELECTRICAL TESTING
LABORATORY AND NELA PARK

Rough Rolled Glass

ROUGH ROLLED PLATE GLASS

In thickness of $\frac{3}{16}$ " in plates up to 72" long by 123" wide, $\frac{1}{4}$ " in plates up to 123" long by 216" wide, in $\frac{21}{64}$ " up to 150" long by 260" wide, in $\frac{1}{2}$ " and $\frac{3}{8}$ " up to 72" long by 160" wide, in $\frac{3}{4}$ " to $1\frac{1}{4}$ " in plates up to 70" long by 130" wide.

This is the clear glass with a knurled surface pattern which is the rough stock for grinding and polishing into plate glass. Where transparency and flat parallel polished surfaces are not needed, this may serve. This can be Herculite Rough Glass up to 108" long by 72" wide.

Tapestry is a rough rolled glass of unusual texture particularly adapted to more ornamental glazing and is available in $\frac{7}{32}$ " thickness in plates up to 60" long by 144" wide.

Flesh tinted, blue, and Solex rough rolled plate glass are also available for use in decorative transoms, partitions and other similar applications.

PROPERTIES:

In general the same as given under Plate Glass except where altered by the rough surfaces.

FIGURED AND DECORATIVE GLASS

As manufactured by the Mississippi Glass Company and sold by the Pittsburgh Plate Glass Company.

Available in various thicknesses of $\frac{1}{8}$ ", $\frac{7}{32}$ ", $\frac{1}{4}$ ", $\frac{3}{8}$ ", $\frac{1}{2}$ ", $\frac{5}{8}$ ", $\frac{3}{4}$ ", and $\frac{7}{8}$ " depending upon the pattern.

REGULAR ROLLED GLASS in patterns as follows:

Hammered, Ribbed, Solite, Hylite, Pentecor, Factrolite, Luxlite, Syenite, Florentine, Astralite, Maze, Dewlite, Aurora, Prestlite, Translite, Artex, Bevelite, Bandlite, Bar-lite, and Pluralite.

WIRE GLASS is available in various patterns in both rough and polished. A square mesh, Misco, may be had in addition to the more common twisted type wire.

GLARE REDUCING FINISH may be obtained on any of the various glasses.

POLISHED GLASS—on wire glass, both surfaces are polished, while on figured glasses, only one face may be polished.

CORRUGATED WIRE GLASS, in regular and in Coolite (heat-absorbing), may be had for roofing and siding.

CATHEDRAL AND OPAL GLASS in various plain and variegated colors.

COOLITE HEAT-ABSORBING GLASS

Available in flat glass, in hammered and ribbed in $\frac{1}{8}$ " and $\frac{1}{4}$ " thickness; also in $\frac{1}{4}$ " wire. Available also in corrugated form. This glass is accepted as complying with government specifications for Type H heat-absorbing glass, and is quite effective in reducing the sun-heat transmission through the window as well as the glare.

PC Glass Block

DESCRIPTION

PC Glass Blocks are partially evacuated, completely sealed hollow units formed by fusing together 2 halves of pressed glass. Edges are coated with a grit-bearing plastic material to insure permanent and effective bond with Portland cement mortar in which glass blocks are normally set.

Patterns range from highly translucent to reasonably transparent in quality, and include prism light-directing and diffusing units with low light transmission.

Available in 3 sizes: $5\frac{3}{4}$, $7\frac{3}{4}$ and $11\frac{3}{4}$ inches square in face dimension by $3\frac{7}{8}$ inches in overall thickness. Special shapes for corner pieces are made in $5\frac{3}{4}$ and $7\frac{3}{4}$ inch sizes, and special radial units for curved panels in $7\frac{3}{4}$ inch size.

PROPERTIES

Individual Units

Light transmission—50%-85% depending upon pattern.

Bond strength (Modulus of Rupture)—100 lbs./sq. in.

Internal air pressure— $\frac{1}{3}$ atmosphere.

Panels of units set in Portland cement mortar.

Crushing strength—400 to 600 lbs./sq. in. under edgewise loading.

Lateral strength (Wind Resistance)—55 lbs./sq. ft. at maximum area limit (144 sq. ft. recommended maximum unsupported area).

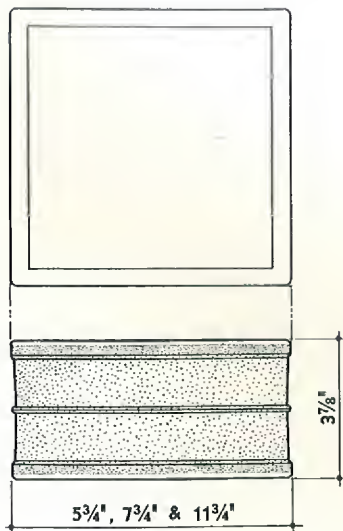
Thermal insulation—(Overall coefficient of heat transfer or U value)—0.49 B.t.u./sq. ft./degree F. differential (15 mile per hour wind on exterior).

Solar heat transmission—20 to 30% of total solar heat incident on vertical panels.

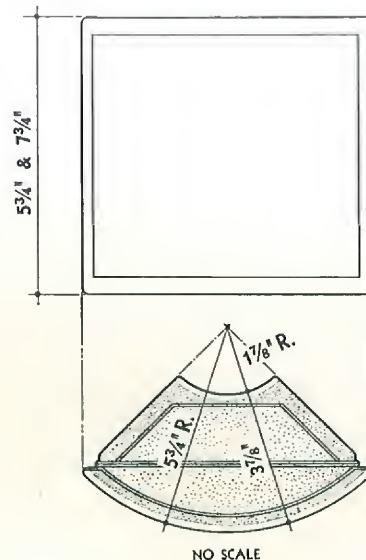
Sound reduction—37.6 to 42.0 decibels over frequencies from 128 to 3200 cycles per sound.

Illumination—Data relative to specific problems available upon application.

SQUARE BLOCKS

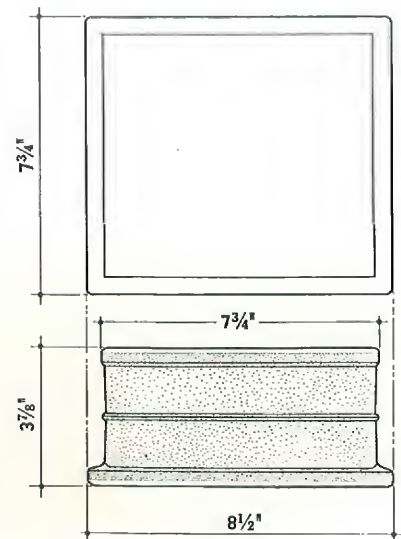


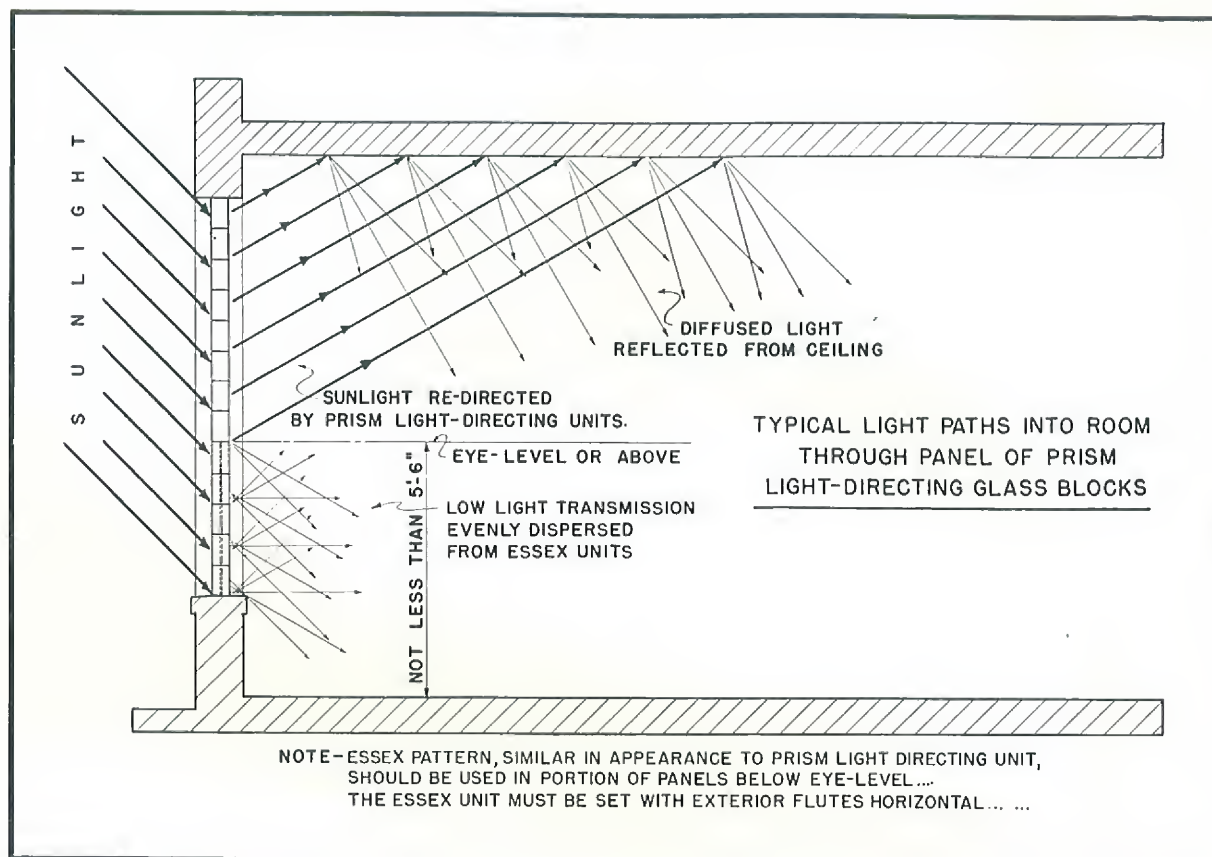
CORNER BLOCKS



NO SCALE

RADIAL BLOCKS





SOLAR HEAT GAIN

The use of glass blocks results in a marked reduction in the total solar heat gain as compared with ordinary windows. This factor is of considerable advantage in buildings that are properly air-conditioned, but does not eliminate the need for adequate ventilation or shading in non-air-conditioned rooms.

Based upon extensive tests, suggested figures for design computations are a maximum hourly rate of 41 B.T.U. and maximum daily rate of 250 B.T.U. total heat gain per square foot of glass block panel on South exposure, 40 degrees North Latitude for August 1.

For more complete data on solar radiation, refer to the current edition of the Heating, Ventilating and Air Conditioning Guide of the American Society of Heating and Ventilating Engineers.

LIGHT TRANSMISSION AND DISTRIBUTION

Various patterns of PC Glass Blocks may be classified as:

1. Semi-Diffusing (Argus, Argus Parallel Flutes, Decora, Reeded Decora, Saxon, Druid, Bristol).
2. Diffusing (Essex).
3. Light-Directing (Prism Light-Directing).

The semi-diffusing blocks afford a partial diffusion of transmitted light by virtue of the optical effect of the patterns impressed on the faces.

The diffusing blocks accomplish a more complete diffusion of transmitted light because of the specially designed patterns impressed in the inside as well as the outside surface of the block.

The light-directing blocks redirect transmitted light by means of optical refraction in horizontal prisms pressed into the inside block faces. Illumination on working areas is provided by reflection of light from the ceiling, and sunlight is directed almost entirely outside the field of normal vision so that glare conditions are virtually eliminated. In the diagram above, typical light paths are shown.

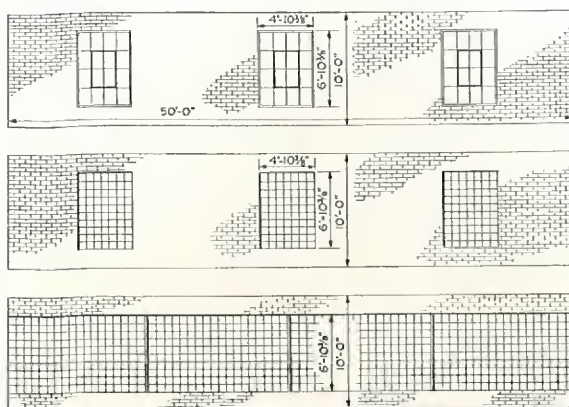
LIGHT TRANSMISSION—SINGLE BLOCKS

Light transmission measurements through the faces of individual glass block units have been made by two somewhat different methods in the absence of any generally accepted standard. Average values for each PC Glass Block pattern are:

Argus	80% (of incident light)
Argus Parallel	80% (of incident light)
Bristol	70% (of incident light)
Decora	80% (of incident light)
Reeded Decora	80% (of incident light)
Druid	80% (of incident light)
Essex	50% (of incident light)
Prism Light-Directing	65% (of incident light)
Saxon	80% (of incident light)
Vue	85% (of incident light)

SOUND INSULATION

Glass block panels have sound insulation properties equal to or better than other forms of masonry construction having equal weight per unit surface area, and are decidedly superior to single-glazed sash. Tests give sound reduction factors for standard glass block panels of 37.6 to 42.0 decibels.



8" brick wall (area 50' x 10')— $\frac{3}{4}$ " plaster on furred metal lath. Temperature inside 70°F.—outside 0°F. Wind at 15 m.p.h.

CRUSHING STRENGTH

Repeated tests made on square wassettes laid up with PC Glass Blocks show a minimum panel compressive strength of 400 to 600 lbs. per sq. in. of gross loaded area. This crushing strength is well above that of many accepted masonry constructions, and is entirely adequate to resist safely the forces created by conditions within the glass block panels themselves.

However, glass block construction should never be used for load-bearing walls or panels. Adequate provision must be made for the support of construction above glass block panels, and expansion joints must be provided at head and jambs of all panels in exterior walls.

BOND STRENGTH

PC Glass Blocks have a special grit-bearing, moisture-and-alkaline-resisting, plastic coating on all mortar edges. This insures a complete and permanent bond between the glass and the cement mortar and provides a panel construction having a high degree of wind resistance and water-tightness.

WIND RESISTANCE

From wind pressure tests on PC Glass Block Panels ranging in area from 50 sq. ft. (5' x 10') to 256 sq. ft. (16' x 16'), it has been found that any panel properly supported at its edges and within the area limits^a recommended will withstand a wind load of 20 lbs. per sq. ft. with a factor of safety of at least 2.7.

^aFor area-limits recommended for PC Glass Block panels, consult panel size limitation data on pages 3 and 4, Section H-11.

WEATHER RESISTANCE

Under all sorts of weather conditions, PC Glass Block construction has proved its durability. Tests of panels subjected to repeated cycles of heating, water spray and freezing show no sign of cracking or other structural deterioration, although temperatures well above and below those encountered in any exposure have been regularly used.

Experience, both in the laboratory, where some 4000 sq. ft. of panels 8' x 10' in size have been tested, and also in the

TOP

With 100 sq. ft. of single-glazed steel sash in three openings—

Heat losses—
 Through brick 8960 B.T.U. per hr.
 Through sash 7910 B.T.U. per hr.
 Through total wall area..16870 B.T.U. per hr.

MIDDLE

With 100 sq. ft. of 8" PC Glass Blocks in three panels—

Heat losses—
 Through brick 8960 B.T.U. per hr.
 Through glass blocks..... 3130 B.T.U. per hr.
 Through total wall area..12390 B.T.U. per hr.

Heat loss through light-transmitting area less than half, with a reduction of 26% of total heat loss through the entire wall.

BOTTOM

With 310 sq. ft. of 8" PC Glass Blocks—

Heat losses—
 Through brick 3580 B.T.U. per hr.
 Through glass blocks.....11660 B.T.U. per hr.
 Through total wall area..15240 B.T.U. per hr.

Heat loss 90% of top panel, but with twice as much light.

field where records of a number of jobs are available, conclusively indicates that properly constructed panels of PC Glass Blocks will be free from leakage.

THERMAL INSULATION

Tests run during the past several years have established values for the over-all coefficient of heat transfer "U" as 0.40 to 0.43 for panels of 8-in. block constructed in the recommended manner. In computing heat losses through panels for design purposes, it is recommended that a "U" value of 0.49 be used for all block sizes and face patterns.

SURFACE CONDENSATION

Condensation will not start forming on the room side of glass block panels until the outside air has reached a temperature much lower than that necessary to produce condensation on single-glazed windows.

OUTDOOR TEMPERATURE REQUIRED TO PRODUCE CONDENSATION ON THE ROOM SIDE SURFACE OF PC GLASS BLOCK PANELS

For example, with inside air at 70°F. and relative humidity at 40%, condensation will not begin to form on the interior surfaces of a glass block panel until an outdoor temperature of -14°F. is reached. Under similar conditions with single-glazed steel sash, moisture will begin to form when the outdoor temperature reaches +33°F.

ESTIMATING DATA

(For 100 sq. ft. of panel laid with $\frac{1}{4}$ -in. visible mortar joints.)

Size of Block	6"	8"	12"
Number of Blocks....	400	225	100
Weight of Panel.....	2000 lbs.	1800 lbs.	1900 lbs.
Volume of Mortar....	4.3 c.f.	3.2 c.f.	2.2 c.f.

PC Foamglas

This comparatively new product is a true glass which has been foamed or cellulated by the evolution of internal gas under pressure at high temperature. It is inorganic, lightweight, of considerable strength, and has the outstanding feature of possessing a closed cell structure. These unique qualities of PC Foamglas recommend it for use in roofs, walls, ceilings, partitions and insulated shields and screens—wherever permanent insulating efficiency is desired. Being glass, it is impervious to moisture, acid atmosphere, vapors, and fumes, and is vermin proof and noncombustible.

The closed cell feature indicates the virtue of the material as an insulant in low temperature work where condensation is a factor, eliminating the necessity for sealing that exists with all other insulating materials now so used.

An examination of the data on properties will immediately suggest that this material's uses may be included under 3 general headings as follows:

As an insulating component of a building unit for roofs, walls, floors and ceilings.

Bulk insulation in cold storage rooms.

As a buoyant material for various types of floats.

PROPERTIES:

Absorption.....	.03 lbs./sq. ft. of surface area (all at surface)
Capillarity	0
Coefficient of expansion....	.000005 inches or feet/°F. temperature change
Combustibility.....	Incombustible (Und. Lab.)
Composition.....	Inorganic (glass)
Compressive strength.....	150 lbs./sq. in.
Electrical resistivity....	The Specific Resistance in ohms/CM ² = 3.6 x 10 ¹⁰ at 20°C.
Flexural strength (Modulus of Rupture).....	90 lbs./sq. in.
Hygroscopicity.....	0% increase in weight after 33 days in 90% Relative Humidity Air
Impact strength.....	66 foot-pounds
K (Conductivity at 50°F. Mean Temp.).....	0.40 B.t.u./hr./sq. ft./°F./in.
K (Conductivity at 300°F. Mean Temp.).....	0.55 B.t.u./hr./sq. ft./°F./in.
Modulus of elasticity.....	163,000 lbs./sq. in.
Resistance to acids.....	Impervious to all acids and acid fumes except hydrofluoric and glacial phosphoric
Specific gravity.....	.168
Specific heat.....	.163 B.t.u./lb.
Thermal diffusivity.....	.53/sq. ft./day/ft.
Water penetration.....	Depth of open surface cells about 1/32"
Water vapor diffusivity.....	0
Weight.....	10.5 lbs./cu. ft.

The above properties are based on an average weight of 10.5 pounds per cubic foot. The material is supplied in a weight range from 9.5 pounds to 11.5 pounds per cubic foot.

Mississippi Glass

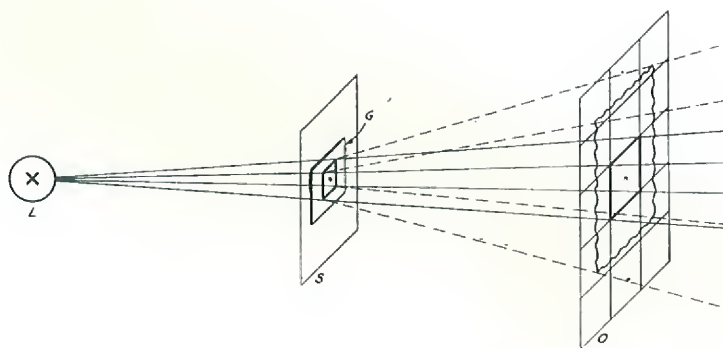


DIAGRAM SHOWING SET-UP USED IN MAKING THE TESTS OF DISTRIBUTION OF LIGHT THROUGH FIGURED SHEET GLASS

L—Concentrated light source. S—Screen with square aperture, area equals one square inch. G—Glass—Test sample. O—Receiving plate divided into squares upon which light impinges. Area of squares equals 4 square inches. Distance—Light source L to Screen S and Screen S to Screen O equals 12 inches.

DISTRIBUTION OF LIGHT AFTER PASSING THROUGH FIGURED SHEET GLASS

A square aperture cut in an opaque surface is placed in the path of light emanating from a concentrated filament source. The beam thus formed is allowed to fall normally upon a flat surface divided into squares equal in area to the bright patch of light falling upon it.

Each sample of glass in turn is placed in front of the aperture and brightness measurements made in each of the

squares where a sufficient amount of light to record is available.

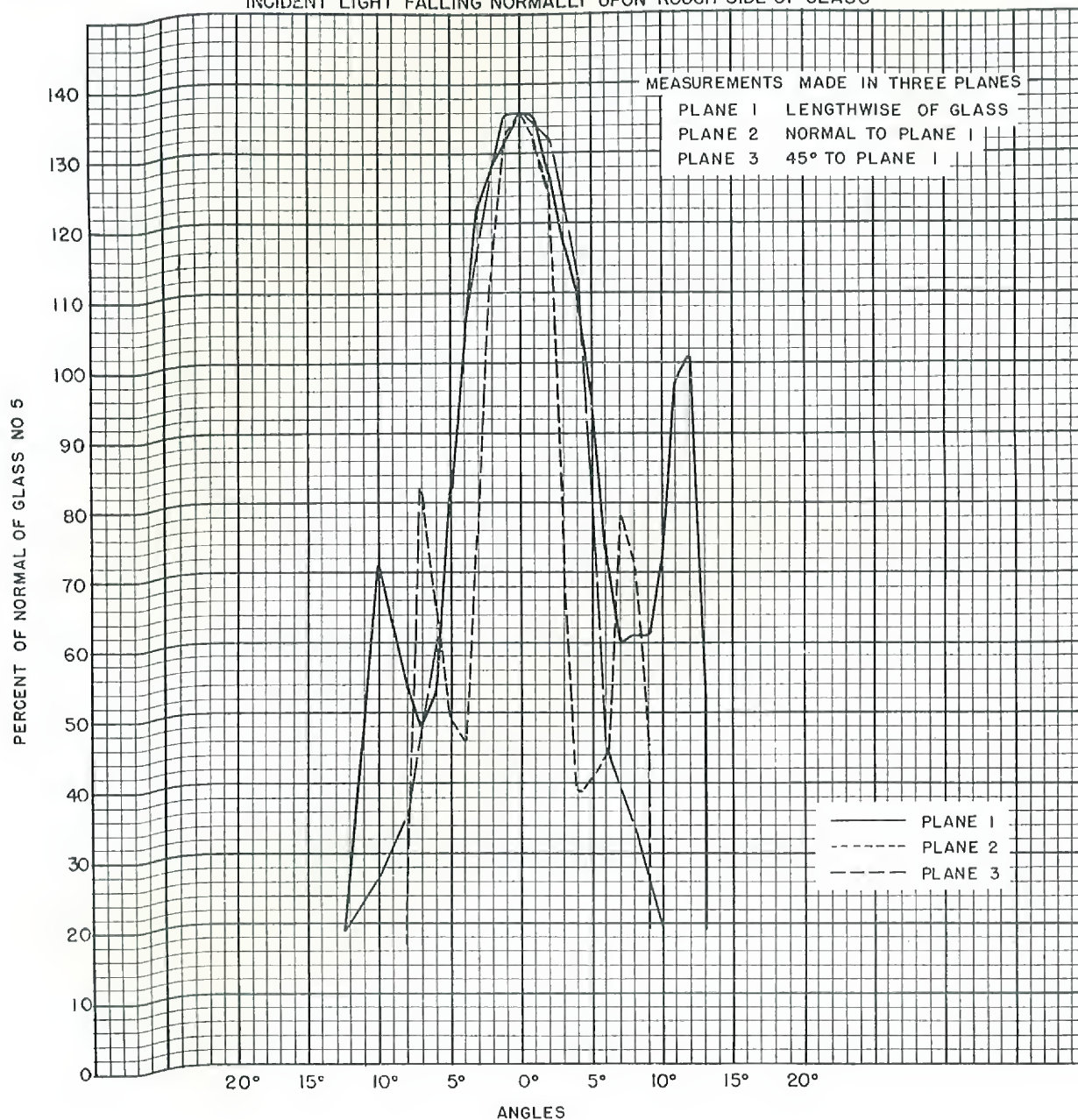
The brightness of the patch of light with no glass interposed is considered as 100%. The results are expressed in terms of the brightness of this patch.

Photographs of the light as distributed by each sample of glass and the per cent brightness in each of the squares are available from Mississippi Glass Company on request.

DISTRIBUTION OF LIGHT THROUGH FACTROLITE GLASS

REPORT BY ELECTRICAL TESTING LABORATORIES

INCIDENT LIGHT FALLING NORMALLY UPON ROUGH SIDE OF GLASS



MISSISSIPPI GLASS

The Mississippi Glass Company produces 2 types of glass, designed especially for use in industrial buildings to accomplish certain definite results. Factrolite is designed for use in vertical openings while Pentecor is intended for use in pitched skylights. The accompanying charts and condensed data will be of service when determining the glass to specify for special purposes.

FACTROLITE

The distribution of light transmitted through Factrolite

with the light incident on the rough side of the glass has been measured in three separate planes with light from a small dimension filament lamp, three feet distant from the glass, falling normally upon and passing through the glass. The emergent light intensities were measured at varying angles with the glass. The measurements were made in three planes; plane #1 lengthwise of the glass, plane #2 at right angles to plane #1, and plane #3 at 45° to plane #1.

The light transmission measurements shown in table #2 were made first with unidirectional light falling normally upon the surface of the glass and second, with diffused light falling upon the glass. In making the latter measurements a hemisphere of uniform brightness was employed.

TABLE No. 1

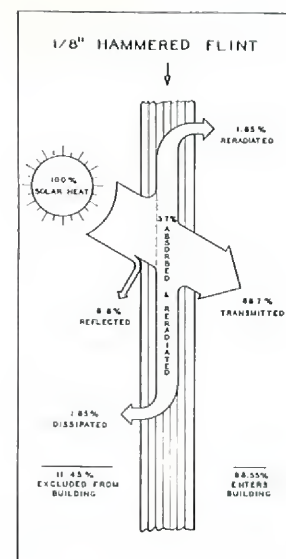
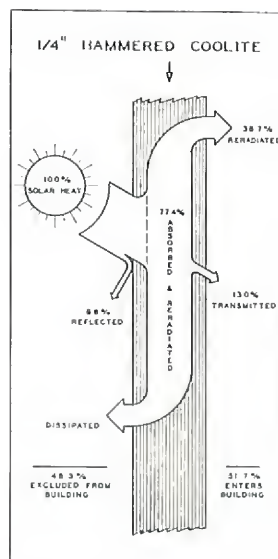
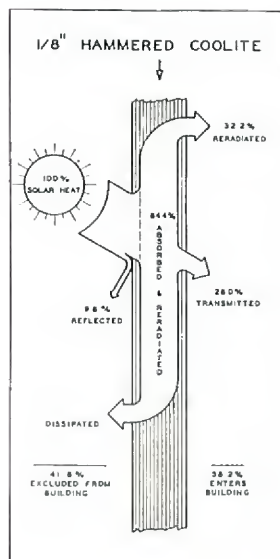
Distribution of Light Transmitted through Factrolite figured glass, Incident light normal to rough side of glass.

Relative light intensities in per cent of maximum.						
Angles	Plane 1		Plane 2		Plane 3	
	Right	Left	Right	Left	Right	Left
0°	100	100	100	100	100	100
1°	100	100	97	98		
2°	93	94	92	82	97	95
3°	86	90	52	56		
4°	81	76	29	34	82	78
5°	70	60	30	36		
6°	54	39	32	48	34	45
7°	44	35	57	60		
8°	45	40	52	16	25	27
9°	45	46	33			
10°	53	52			14	20
11°	72	36				
12°	74					
13°	40					

TABLE No. 2
Transmission of Light

Sample	Side toward Light	Transmission Factor	
		Unidirectional Light	Diffused Light
Factrolite Glass	Rough	0.885	0.78
	Smooth	0.885	0.78

Note: Plane 1, lengthwise of glass.
Plane 2, normal to Plane 1.
Plane 3, 45° to Plane 1.



Solar energy transmission and absorption.

COOLITE

The interception of solar heat by Coolite is the result of several factors. When the rays of the sun strike a Coolite window, some of them pass directly through the glass, a small portion is turned back by surface reflection; the remainder is absorbed by the special ingredients in the glass. (See Schematic diagram.)

1/8" Polished Coolite, by reflection and absorption, intercepts approximately 85% of the solar heat while 15% passes

through the glass without interference. The energy that is absorbed raises the temperature of the glass which then theoretically re-radiates heat equally from both the inner and outer surfaces. Actually, however, more than half of this heat is dissipated outside the building because of greater air circulation out of doors.

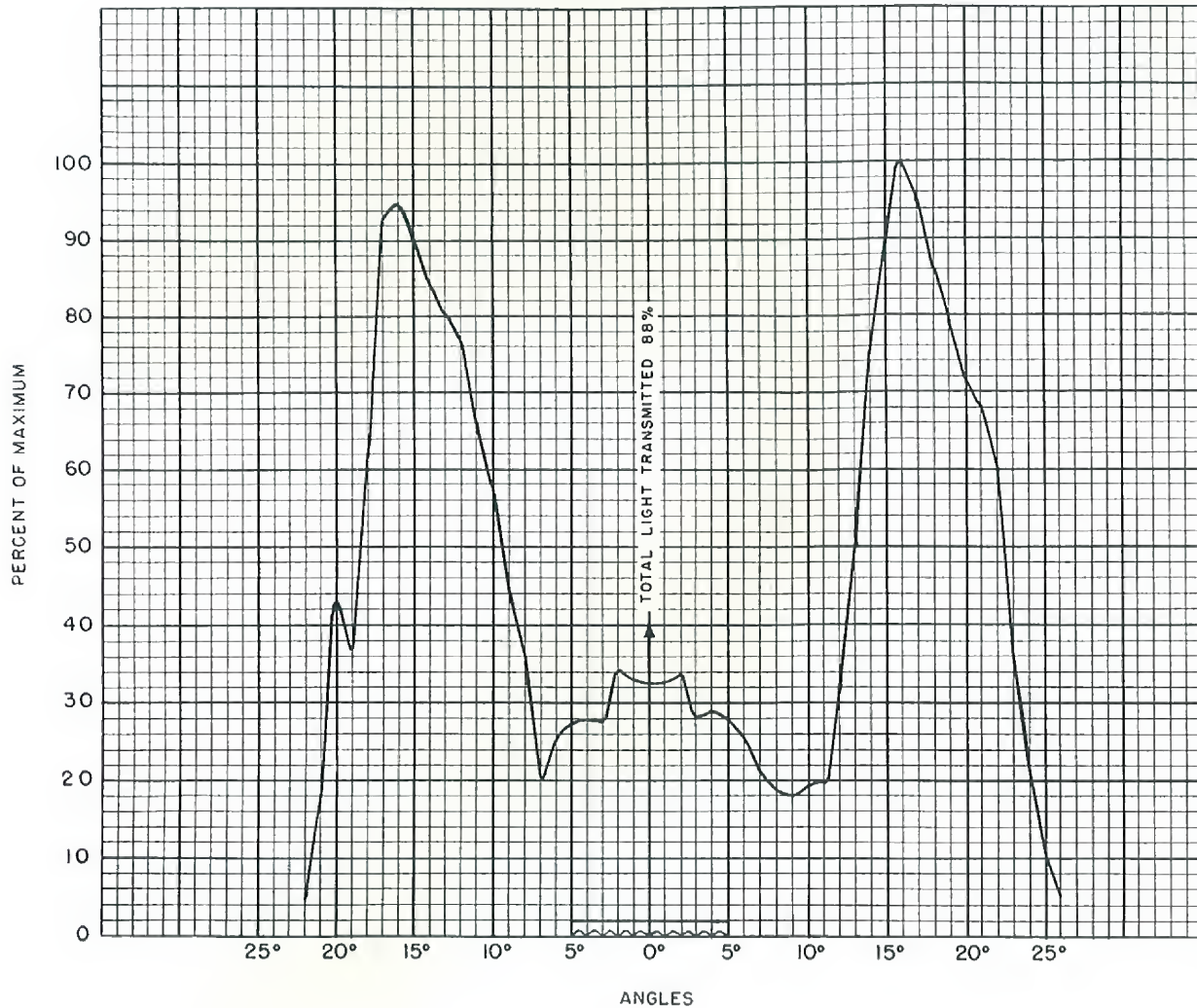
Coolite is furnished in a variety of surface patterns and in the special Glare Reducing Finish, which are factors contributing to the interception of heat, as well as the distribution and control of light.

DISTRIBUTION OF LIGHT THROUGH "NEW PENTECOR" GLASS

REPORT BY ELECTRICAL TESTING LABORATORIES

INCIDENT LIGHT FALLING NORMALLY UPON PRISM SIDE.

PLANE OF MEASUREMENTS PERPENDICULAR TO PRISM.



PENTECOR

The distribution of light through Pentecor glass was measured with the incident light falling normally upon the rough side of the glass. Measurements were made in plane at right angles to the prism of the glass surface. The light source used was a filament of small dimension, approximately 0.1 x 0.1 of an inch, placed at a distance of three feet from the glass. Light distribution measurements were made by observations of the light through the glass. The observa-

tions were taken at different angles as noted on the chart.

The values of the light transmitted through the sample are in per cent of the maximum.

Light transmission was determined first with unidirectional light falling normally upon the surface of the glass and, second, with diffused light falling upon the glass. In making the latter measurements, a hemisphere of uniform brightness was employed. The light distribution data are shown on the chart and in table #1, while the light transmission values are shown in table #2.

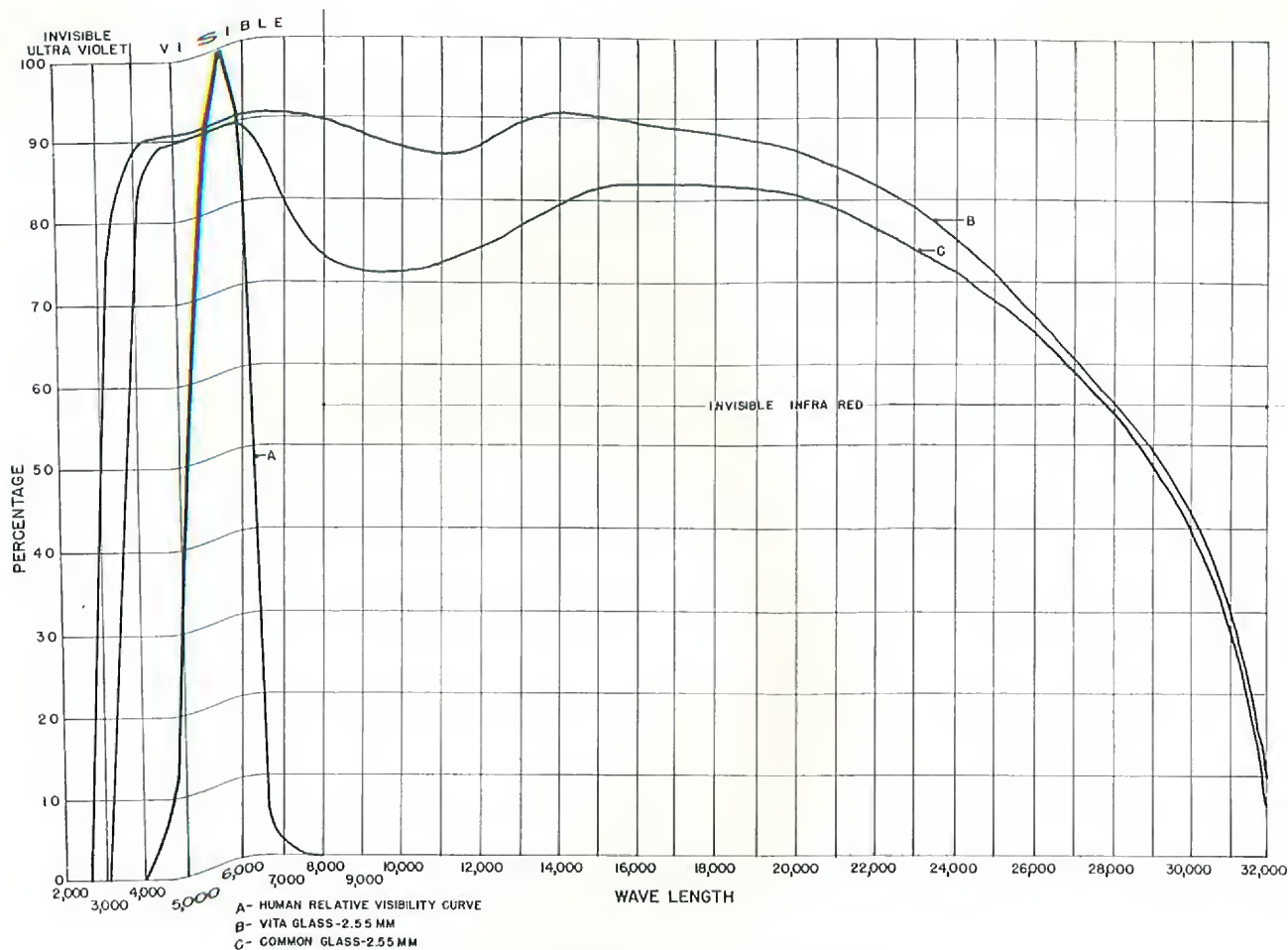
TABLE No. 1

Distribution of Light Transmitted through Pentecor figured glass, Incident light normal to rough side of glass.

Relative light intensities in per cent of maximum.		
Angles	Left	Right
0°	32.5	32.5
1°	33.0	32.5
2°	34.3	33.9
3°	27.7	28.0
4°	28.0	28.9
5°	27.8	28.0
6°	25.7	25.7
7°	20.0	21.4
8°	35.7	18.4
9°	42.8	17.9
10°	57.2	18.9
11°	66.1	19.7
12°	76.8	32.2
13°	80.4	50.0
14°	83.9	75.0
15°	89.3	89.3
16°	94.7	100.0
17°	92.8	94.6
18°	62.5	85.7
19°	37.2	78.6
20°	42.8	71.4
21°	17.9	67.9
22°	4.8	59.0
23°		35.7
24°		21.4
25°		9.8
26°		4.8

TABLE No. 2
Transmission of Light

Sample	Side toward Light	Transmission Factor	
		Unidirectional Light	Diffused Light
Pentecor	Rough	0.88	0.685
Glass	Smooth	0.88	0.685



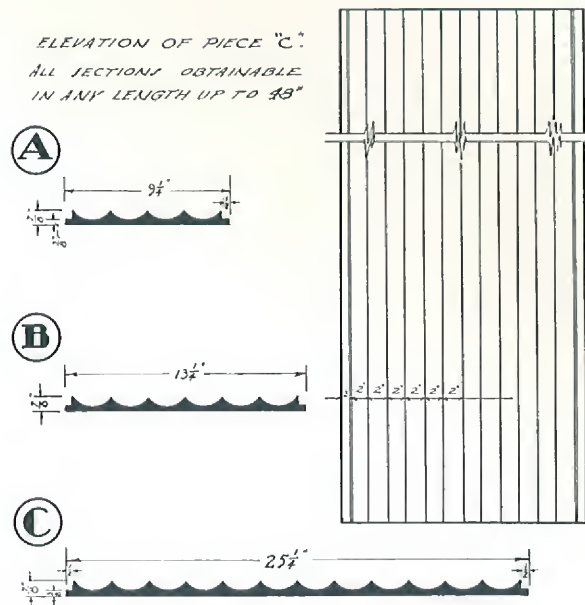
Radiant Energy Transmission of Vita Glass

VITA GLASS

The physical and mechanical properties of Vita Glass, except for light transmission are essentially identical with those for plate glass or window glass as given in Sections J-1 and J-3. The transmission values for Vita Glass as compared with other window glass, not especially ultra-violet transmitting, and as compared with the human relative visibility curve, are shown in the chart. The values used in plotting this chart are those for new glass. After several months exposure to direct sunlight, the ultra-violet transmission values, particularly, will be reduced approximately 50%.

The ultra-violet radiation of therapeutic value lies entirely to the left, or outside of, curve C and the limit of solar ultra-violet radiation reaching the earth's surface lies essentially at the point where curve B intersects the 0 base line. In other words, ordinary window glass transmits essentially no ultra-violet of therapeutic value while Vita Glass under optimum conditions will transmit an average of 25% of therapeutically useful ultra-violet.

Pressed Prism Plate Glass



PATTERN No. 300

Panels A, B and C represent three different widths of the general design Number 300. The details for the three pieces are relatively the same except that more flutes have been added to obtain the greater widths.
All of the three pieces can be obtained in any length up to and including 48".

SPECIFICATIONS

GLASS—Crystal only.

FINISH—

- (1) Clear face, matted back, sides cut, ends ground.
 - (2) Clear face, polished back, sides cut, ends ground.
 - (3) Clear face, polished back, sides cut, ends ground.
- Note: polishing the back reduces thickness of the glazing lip to approximately $\frac{3}{16}$ ".

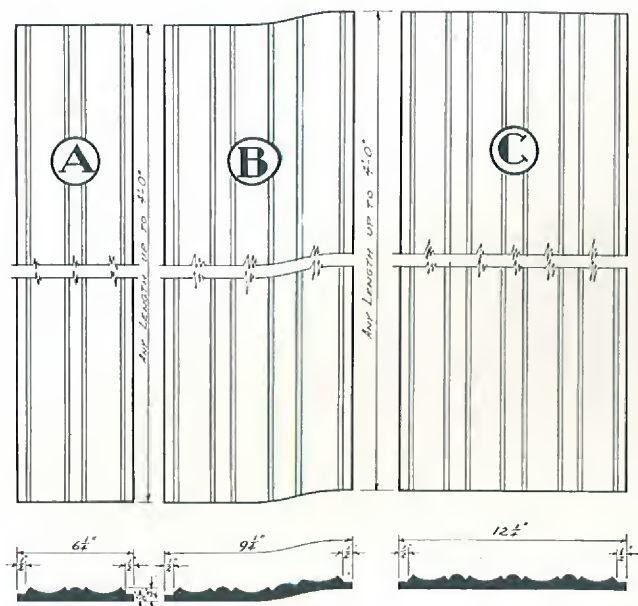
Note: The silvering on the back of finish (3) will be furnished with a protective film of electrolytically-deposited copper, but nevertheless ample consideration should be given to protection of the mirror backing in the installation proper. See Section H-1.

WEIGHT—(Approximate)

Finish (1)	Finishes (2) and (3)
A — 5.5.....	4.4 lbs. per linear foot
B — 7.5.....	5.9 lbs. per linear foot
C — 15.3.....	12.1 lbs. per linear foot

CLEARANCE—The opening to receive the glass should be $\frac{1}{4}$ " wider than the width dimensions noted above, since a tolerance of $\frac{1}{8}$ " is necessary in cutting the individual glazing lips.

INSTALLATION—Suggestions will be found in Section H-13 of this Glass Manual.



PATTERN No. 301

Panels A, B and C represent three different widths of the general design Number 301. All details are the same for the three panels except that more flutes have been added to obtain the greater widths.

All of the three pieces can be obtained in any length up to and including 48".

SPECIFICATIONS

GLASS—Crystal only.

FINISH—

- (1) Clear face, matted back, sides cut, ends ground.
- (2) Clear face, polished back, sides cut, ends ground.

Note: Polishing the back reduces thickness of the glazing lip to approximately $\frac{3}{16}$ ".

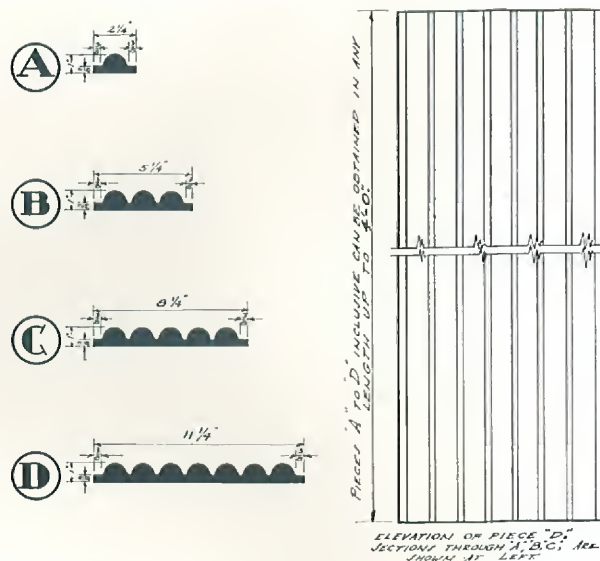
- (3) Clear face, mirrored back, sides cut, ends ground.
- Note: The silvering on the back of finish (3) will be furnished with a protective film of electrolytically-deposited copper, but nevertheless ample consideration should be given to protection of the mirror backing in the installation proper. See Section H-4.

WEIGHT—(Approximate)

Finish (1)	Finishes (2) and (3)
A — 3.7.....	3.0 lbs. per linear foot
B — 5.6.....	4.5 lbs. per linear foot
C — 7.5.....	6.0 lbs. per linear foot

CLEARANCE—The opening to receive the glass should be $\frac{1}{4}$ " wider than the width dimensions noted above since a tolerance of $\frac{1}{8}$ " is necessary in cutting the individual glazing lips.

INSTALLATION—Suggestions will be found in Section H-13 of this Glass Manual.



PATTERN No. 302

Panels A, B, C and D represent four different widths of the general design Number 302. The details for the four pieces are relatively the same except that more reeds have been added to obtain the greater widths.

All of the four pieces can be obtained in any length up to and including 48".

SPECIFICATIONS

GLASS—Crystal only.

FINISH—

- (1) Clear face, matted back, sides cut, ends ground.
 - (2) Clear face, polished back, sides cut, ends ground.
- Note: Polishing the back reduces thickness of the glazing lip to approximately $\frac{3}{16}$ ".

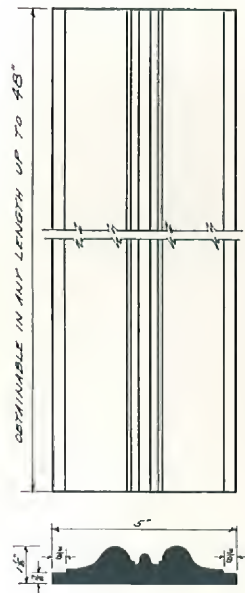
- (3) Clear face, mirrored back, sides cut, ends ground.
- Note: The silvering on the back of finish (3) will be furnished with a protective film of electrolytically-deposited copper, but nevertheless ample consideration should be given to protection of the mirror backing in the installation proper. See Section H-4.

WEIGHT—(Approximate)

Finish (1)	Finishes (2) and (3)
A — 1.7.....	1.1 lbs. per linear foot
B — 4.3.....	3.7 lbs. per linear foot
C — 6.7.....	5.7 lbs. per linear foot
D — 9.1.....	7.7 lbs. per linear foot

CLEARANCE—The opening to receive the glass should be $\frac{1}{4}$ " larger than the dimensions noted above, since a tolerance of $\frac{1}{8}$ " is necessary in cutting individual glazing lips.

INSTALLATION—Suggestions will be found in Section H-13 of this Glass Manual.



PATTERN No. 303

This very unusual section is well adapted to strip illumination, or for feature work on pilasters and facias of commercial buildings.

SPECIFICATIONS

GLASS—Crystal only.

FINISH—

- (1) Clear face, matted back, sides cut.
- (2) Clear face, polished back, sides cut.
- Note: Polishing the back reduces thickness of the glazing lip to approximately $\frac{3}{16}$ ".

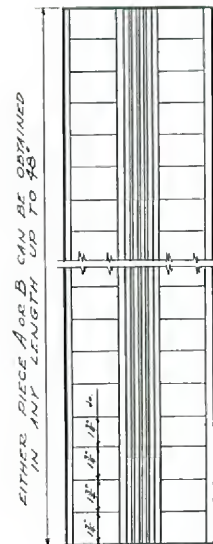
(3) Clear face, mirrored back, sides cut, ends ground.
 Note: The silvering on the back of finish (3) will be furnished with a protective film of electrolytically-deposited copper, but nevertheless ample consideration should be given to protection of the mirror backing in the installation proper. See Section H-4.

WEIGHT—(Approximate)

Finish (1)	Finishes (2) and (3)
3.6.....	3.0 lbs. per linear foot

CLEARANCE—The opening to receive the glass should be $\frac{1}{4}$ " larger than the dimensions noted above, since a tolerance of $\frac{1}{8}$ " is necessary in cutting the individual glazing lips.

INSTALLATION—Suggestions will be found in Section H-13 of this Glass Manual.



PATTERN No. 304

Drawing A represents a small cross-lit section of the whole piece B. Though section A is manufactured as a part of B, it may be purchased and used separately. As a thin, decorative strip or when used in front of tube lighting, its variety of uses is practically unlimited.

Whole section B is highly popular as a frame for surrounding other and larger decorative architectural glass.

SPECIFICATIONS

GLASS—Crystal only.

FINISH—

- (1) Clear face, matted back, sides cut, ends ground.
- (2) Clear face, polished back, sides cut, ends ground.
- Note: Polishing the back reduces thickness of the glazing lip to approximately $\frac{3}{16}$ ".

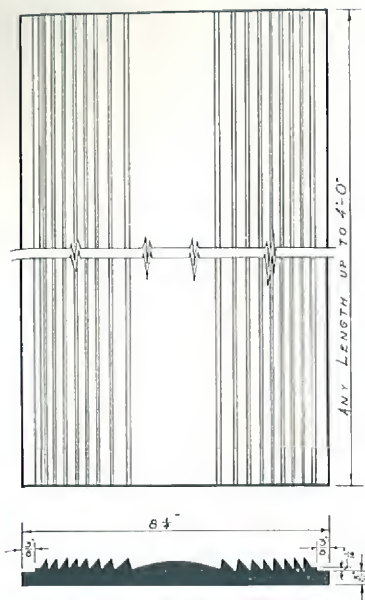
(3) Clear face, mirrored back, sides cut, ends ground.
 Note: The silvering on the back of finish (3) will be furnished with a protective film of electrolytically-deposited copper, but nevertheless ample consideration should be given to protection of the mirror backing in the installation proper. See Section H-4.

WEIGHT—(Approximate)

Finish (1)	Finishes (2) and (3)
3.8.....	1.6 lbs. per linear foot

CLEARANCE—The opening to receive the glass should be $\frac{1}{4}$ " wider than the width dimensions noted above since a tolerance of $\frac{1}{8}$ " is necessary in cutting the individual glazing lips.

INSTALLATION—Suggestions will be found in Section H-13 of this Glass Manual.



PATTERN No. 305

This unique panel is similar in nature to a fresnel lens though in strip form. When used with a polished back in conjunction with Neon or gaseous lighting tubes, the panel is visible at a great distance. With matted back it forms a brilliant strip that is highly decorative.

SPECIFICATIONS

GLASS—Crystal only.

FINISH—

- (1) Clear face, matted back, sides cut, ends ground.
- (2) Clear face, polished back, sides cut, ends ground.
- (3) Clear face, mirrored back, sides cut, ends ground.

Note: Polishing the back reduces thickness of the glazing lip to approximately $\frac{3}{16}$ ".

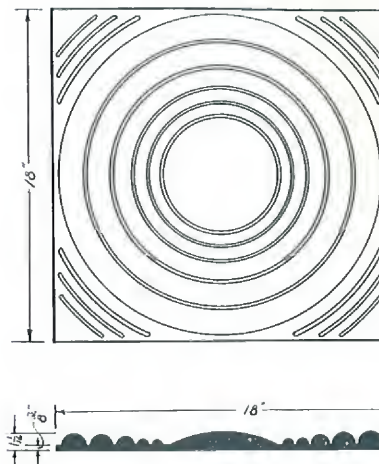
Note: The silvering on the back of finish (3) will be furnished with a protective film of electrolytically-deposited copper, but nevertheless ample consideration should be given to protection of the mirror backing in the installation proper. See Section H-1.

WEIGHT—(Approximate)

Finish (1)	Finishes (2) and (3)
4.6.....	3.6 lbs. per linear foot

CLEARANCE—The opening to receive the glass should be $\frac{1}{4}$ " wider than the width dimensions noted above, since a tolerance of $\frac{1}{8}$ " is necessary in cutting the individual glazing lips.

INSTALLATION—Suggestions will be found in Section H-13 of this Glass Manual.



PATTERN No. 306

This highly decorative panel can be adapted to a wide variety of uses. It is not limited to use as a square but it can be cut to a circle or set in a frame that will mask the corner chevrons.

SPECIFICATIONS

GLASS—Crystal only.

FINISH—

- (1) Clear face, matted back, sides ground.
- (2) Clear face, polished back, sides ground.
- (3) Clear face, mirrored back, sides ground.

Note: Polishing the back reduces thickness of the glazing lip to approximately $\frac{3}{16}$ ".

Note: The silvering on the back of finish (3) will be furnished with a protective film of electrolytically-deposited copper, but nevertheless ample consideration should be given to protection of the mirror backing in the installation proper. See Section H-1.

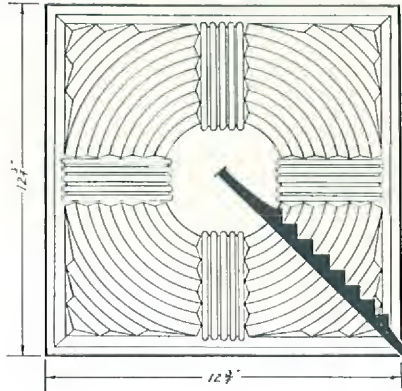
WEIGHT—(Approximate)

Finish (1)	Finishes (2) and (3)
19.5.....	16.0 lbs. each

CLEARANCE—Since all edges of this panel are furnished ground to size, a "joint allowance" of only $\frac{1}{32}$ " need be made at all edges.

INSTALLATION—Suggestions will be found in Section H-13 of this Glass Manual.

Note: Since the center portion of this panel is capable of forming a burning glass, it is suggested that no inflammable material be placed adjacent to the glass.



PATTERN No. 307

Although this panel has somewhat the appearance of a fresnel type lens, its function is decorative only. The corrugations on the surface do nothing more than diffuse transmitted light. When a number of these panels are used together side by side, or to form a large window, an exceptionally pleasing pattern results.

SPECIFICATIONS

GLASS—Crystal only.

FINISH—

(1) Clear face, matted back, sides ground.

(2) Clear face, polished back, sides ground.

Note: Polishing the back reduces thickness of the glazing lip to approximately $\frac{3}{16}$ ".

(3) Clear face, mirrored back, sides ground.

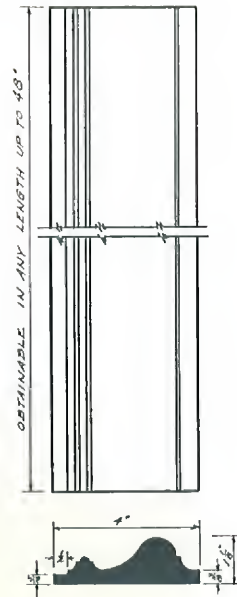
Note: The silvering on the back of finish (3) will be furnished with a protective film of electrolytically-deposited copper, but nevertheless ample consideration should be given to protection of the mirror backing in the installation proper. See Section H-4.

WEIGHT—(Approximate)

Finish (1)	Finishes (2) and (3)
7.0.....	5.8 lbs. each

CLEARANCE—Since all edges of this panel are furnished ground to size, a "joint allowance" of only $\frac{1}{32}$ " need be made at all edges.

INSTALLATION—Suggestions will be found in Section H-13 of this Glass Manual.



PATTERN No. 308

This bolection mold was designed as a practical glass section for trimming openings such as windows, doors and fireplaces.

Any length can be obtained up to and including 48 inches. Miterers are quite easily fabricated where angles or corners occur.

Where the ends of two pieces of this mold abut, it is suggested that those ends be polished instead of ground.

SPECIFICATIONS

GLASS—Crystal only.

FINISH—

(1) Clear face, matted back, sides cut, ends ground.

(2) Clear face, polished back, sides cut, ends ground.

Note: Polishing the back reduces thickness of the glazing lip to approximately $\frac{3}{16}$ ".

(3) Clear face, mirrored back, sides cut, ends ground.

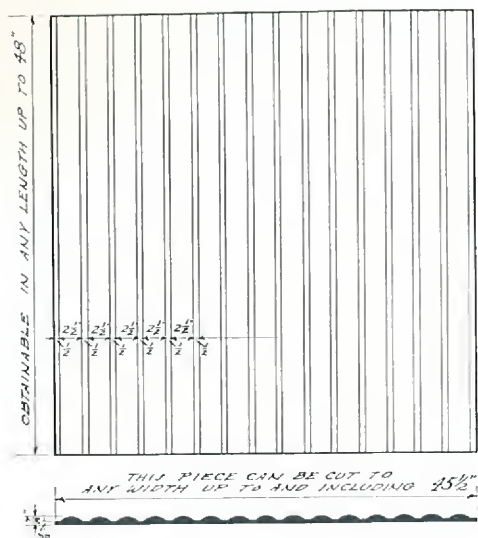
Note: The silvering on the back of finish (3) will be furnished with a protective film of electrolytically-deposited copper, but nevertheless ample consideration should be given to protection of the mirror backing in the installation proper. See Section H-4.

WEIGHT—(Approximate)

Finish (1)	Finishes (2) and (3)
6.5.....	5.5 lbs. per linear foot

CLEARANCE—The opening to receive the glass should be $\frac{1}{4}$ " wider than the width dimensions noted above, since a tolerance of $\frac{1}{8}$ " is necessary in cutting the individual glazing lips.

INSTALLATION—Suggestions will be found in Section H-13 of this Glass Manual.



PATTERN No. 309

The scope of usefulness of this panel is not limited to plates $45\frac{1}{2} \times 48$ inches, but sections may be cut from it. The cuts may be made at any point laterally across the panel, or in any one of the valleys or spaces between the reeds longitudinally. Special cuts through the reeds proper can be performed but the symmetry of the panel is destroyed.

SPECIFICATIONS

GLASS—Crystal only.

FINISH—

(1) Clear face, matted back, all edges ground.

(2) Clear face, polished back, all edges ground.

Note: Polishing the back reduces the overall thickness to approximately $\frac{3}{4}$ ".

(3) Clear face, mirrored back, all edges ground.

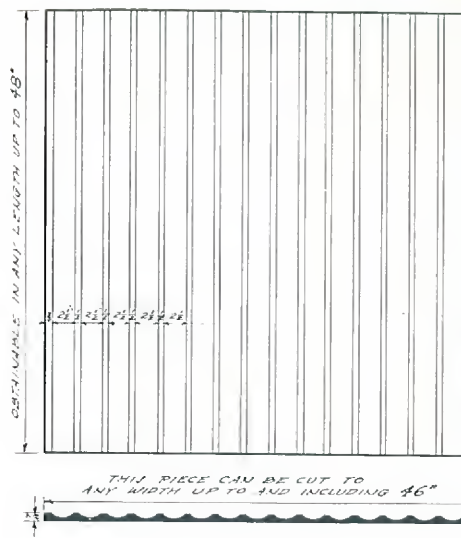
Note: The silvering on the back of finish (3) will be furnished with a protective film of electrolytically-deposited copper, but nevertheless ample consideration should be given to protection of the mirror backing in the installation proper. See Section H-1.

WEIGHT—(Approximate)

Finish (1)	Finishes (2) and (3)
9.4.....	7.9 lbs. per linear foot

CLEARANCE—Since all edges of this panel are furnished ground to size, a "joint allowance" of only $\frac{1}{32}$ " need be made at all edges.

INSTALLATION—Suggestions will be found in Section H-13 of this Glass Manual.



PATTERN No. 310

Though the maximum size of this panel is 46×48 inches, smaller sizes will be found to be equally useful. Lateral cuts may be made at any point and while any longitudinal cut is possible, it is preferred that they be at the bottom of a flute, or on a flat space between the flutes proper.

SPECIFICATIONS

GLASS—Crystal only.

FINISH—

(1) Clear face, matted back, all edges ground.

(2) Clear face, polished back, all edges ground.

Note: Polishing the back reduces the overall thickness to approximately $\frac{3}{4}$ ".

(3) Clear face, mirrored back, all edges ground.

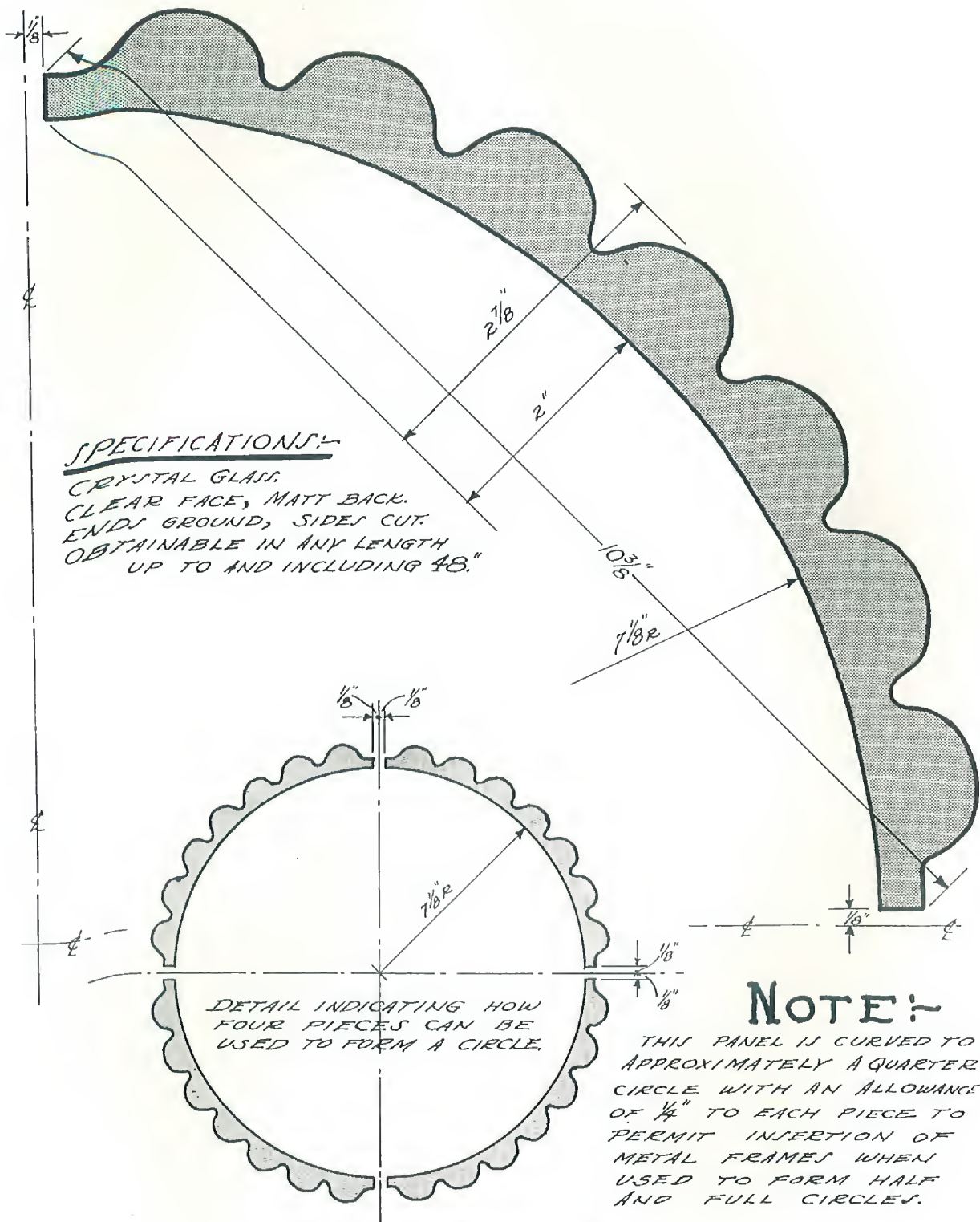
Note: The silvering on the back of finish (3) will be furnished with a protective film of electrolytically-deposited copper, but nevertheless ample consideration should be given to protection of the mirror backing in the installation proper. See Section H-1.

WEIGHT—(Approximate)

Finish (1)	Finishes (2) and (3)
7.5.....	6.0 lbs. per square foot

CLEARANCE—Since all edges of this panel are furnished ground to size, a "joint allowance" of only $\frac{1}{32}$ " need be made at all edges.

INSTALLATION—Suggestions will be found in Section H-13 of this Glass Manual.



Architectural glass panel 402-D

SECTION "K"

LEXICON AND GLOSSARY

K-1

LEXICON OF ARCHITECTURAL TERMS

K-2

GLOSSARY

Lexicon of Architectural Terms

used by Architects and Builders

Abattoir—A place where animals are butchered.
A slaughter-house, especially one operating on a large scale.

Alcove—Commonly used to describe any large recess in a room, generally separated by an ARCH.

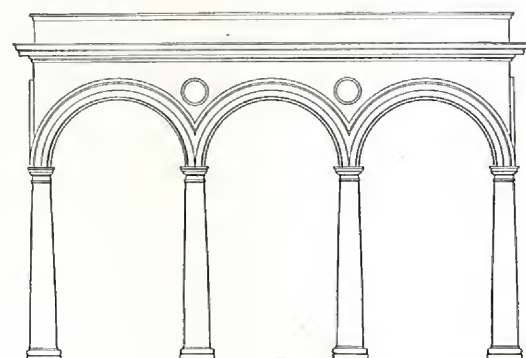
Alumilite—A finish on aluminum.

Apron—A plain or molded piece of finish below the stool of a window, put on to cover the rough edge of the finished PLASTERING. (See illustration Oriel Window "A")

Apse—The eastern or altar end of a church. (See illustration Church Floor Plan "A")

Arcade—A range of ARCHES supported on Columns or on PIERS, and detached or attached to the WALL. (See illustration Arcade)

Arch—A structure spanning an opening in the form of a curve, supported by PIERS or abutments. (See illustration Arcade)



ARCADE

Arris—The meeting of two surfaces producing an angle. (See Glossary)

Ashlar or Ashler—A facing of squared or rectangular pieces of stone or other material, or a facing made of thin slabs, used to cover WALLS. Carrara ashlar—usually 8 inches by 16 inches.

Astragal—A small convex MOLDING or BEAD.

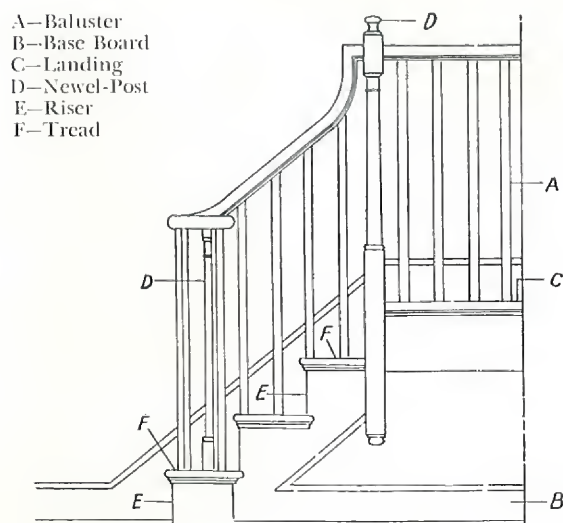
Atelier—Artist's studio, a work shop.

Awning Windows—(See PROJECTED WINDOWS)

Baluster—A small PILLAR or COLUMN, supporting a rail, of various forms, used in BALUSTRADES. (See illustration Balustrade "A")

Balustrade—A series of BALUSTERS connected by a rail. (See illustration Balustrade)

Barricade—Hoarding—a screen of boards, enclosing a construction, or any similar fence.



BALUSTRADE

Base Board—See MOP BOARD. (See illustration Balustrade "B")

Bas-Relief or **Basso-Relievo**—The representations of figures projected from a background without being detached from it.

Bat—A part of a brick.

Batten—Small SCANTLINGS, or small strips of boards, used for various purposes. Small strips put over the joints of sheathing to keep out the weather.

Battlement—A PARAPET with a series of notches in it.

Bay—Any division or compartment of an ARCADE, ROOF, etc.

Bay Window—Any WINDOW projecting outward from the WALL of a building, either square or



BAY WINDOW

polygonal on plan, and commencing from the ground. If they are carried on projecting CORBELS, they are called ORIEL WINDOWS. (See illustration Bay Window)

Bead—A MOLDING. (See illustration Moldings)

Beam—A relatively long piece of timber, steel, stone, or other material, placed horizontally, or nearly so, to support a load over an opening, or from post to post.

Bearing Wall or **Partition**—A WALL or PARTITION which supports the floors and ROOFS in a building. LOAD-BEARING.

Belfry—A tower or campanile containing bells. (See illustration Steeple "A")

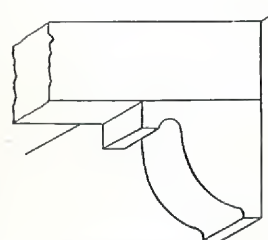
Blueprint—A positive print or reproduction in

blue and white obtained by photographic process from a transparent negative or TRACING DRAWING.

Borrowed Light—The indirect transmission of light from a remote source, such as glazed PARTITIONS between hallways and outside lighted rooms. A secondary lighting from a primary source, hence, borrowed light. A borrowed light is also the sash, light of glass or panel of glass blocks that transmits the light.

Brace—In carpentry, an inclined piece of timber, used in trussed PARTITIONS, or in framed ROOFS, in order to form a triangle, and thereby stiffen the framing. When it is used as a support to a rafter, it is called a strut.

Bracket—A projecting ornament carrying a CORNICE, BEAM shelf, glass shelf or the like. (See illustration Bracket)



BRACKET

Brake Molding—The forming of simple angular shapes by placing a flat sheet of metal in a horizontal machine commonly known as a brake. Brakes can be made in practically any metal by hand power or machine.

Break—Any projection from or recess on the general surface of a building.

Brown Coat—In PLASTERING, the second coat.

Brown Print—Van Dyke, similar to BLUEPRINT, in brown and white.

Bulkhead—An upright partition wall or structure—in a store front, the wall between the sill of the display window and the sidewalk.

Butt-Joint—Where the ends of two pieces of timber or MOLDING butt together.

Caisson—A watertight box or chamber within which submarine construction is carried on—a sunken panel in a ceiling or soffit.

Campanile—Belfry.

Canopy—A suspended covering over a throne, bed or the like, or over the path of a procession. An extended covering over an entrance or doorway. (See illustration Marquee)

Canted Corner—See Chamfer.



EGYPTIAN



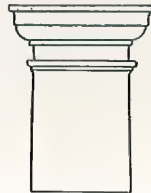
ASSYRIAN



GREEK DORIC



ROMAN DORIC



TUSCAN



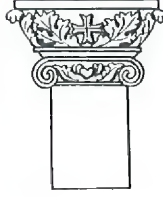
IONIC



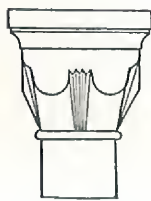
CORINTHIAN



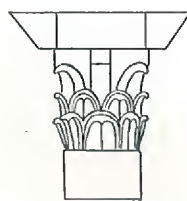
COMPOSITE



BYZANTINE



MEDIAEVAL



MOORISH

COLUMNS AND CAPITALS

Capital—The upper member of a COLUMN or PILLAR. (See illustration Columns and Capitals)

Carton or Cartoon—A DESIGN made on strong paper, to be transferred on the fresh plaster wall to be afterward painted in FRESCO; also a colored design for working in mosaic tapestry.

Casement Doors—See FRENCH DOORS.

Casement Window—A glass frame which is made to open either out or in by turning on hinges affixed to its vertical edges. (See illustration Oriel Window)

Causeway—A raised or paved way, usually across wet or marshy ground.

Cavity Walls—Construction of two individual parallel WALLS of masonry with an air space between them. The air space is usually two inches, however this dimension may be varied. Masonry bond is not used, but the dual walls are connected by metal wall ties. Cavity walls may or may not be LOAD-BEARING. (See CORE WALLS)

Ceiling—That covering of a room which hides the JOISTS of the floor above, or the rafters of the ROOF. (See SUSPENDED OR HUNG CEILING)

Ceiling Lights or Diffusing Lights—SASH or frames placed in a CEILING under a SKYLIGHT or artificial light. Also lights hung from a ceiling.

Ceramic Tiles—Baked vitreous clay in various shapes for floors or WAINSCOTS. ROMAN MOSAICS.

Chair-Rail—A wall MOLDING around a room at the height of a chair back.

Chamfer, Champfer or Chaumfer—When the edge or ARRIS of any work is cut off at an angle of 45 degrees in a small degree, it is said to be chamfered; if to a large scale, it is said to be a canted corner (Seamed, swiped).

Chapel—A sanctuary. A room or building used for worship instead of the main church.

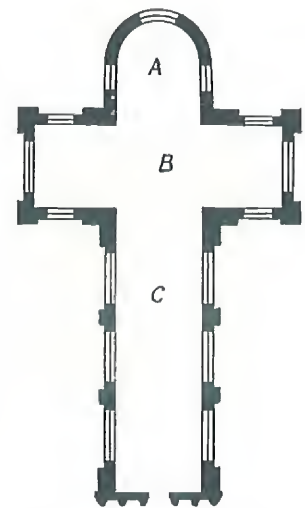
Chase — A GROOVE; trough, trench.

Check Rail Windows—See DOUBLE HUNG WINDOWS.

Cheval Glass—A mirror or glass screen suspended by horizontal pivots in a frame.

Church—A building for religious worship. See illustration.

Circle Window—A window in the form of a circle. (See illustration Circle Window)



CHURCH FLOOR PLAN
A—Apse, B—Transept,
C—Nave

Clapboard — WEATHER BOARDING. (See illustration Weather Boarding)

Clerestory, Clearstory —

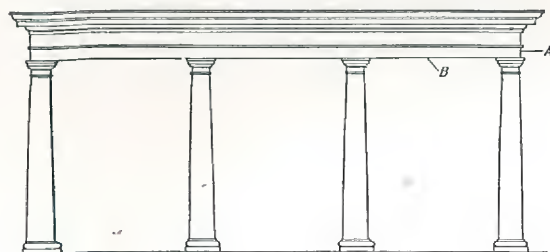
When the middle of the NAVE of a church rises above the aisles and is pierced with WINDOWS, the upper story is thus called. The word clerestory is also used to denote a similar method of lighting other buildings besides churches, especially factories, depots, sheds, etc. (See illustration Rotunda "A")



CIRCLE WINDOW

Cold Rolling—The forming of various shapes by passing a flat strip or ribbon of metal through a series of roll dies. This can be accomplished in practically any metal.

Colonnade—A row of COLUMNS. When in front of a building they are termed PORTICOS; when surrounding a building, PERISTYLE; and when double or more, POLYSTYLE. (See illustration)



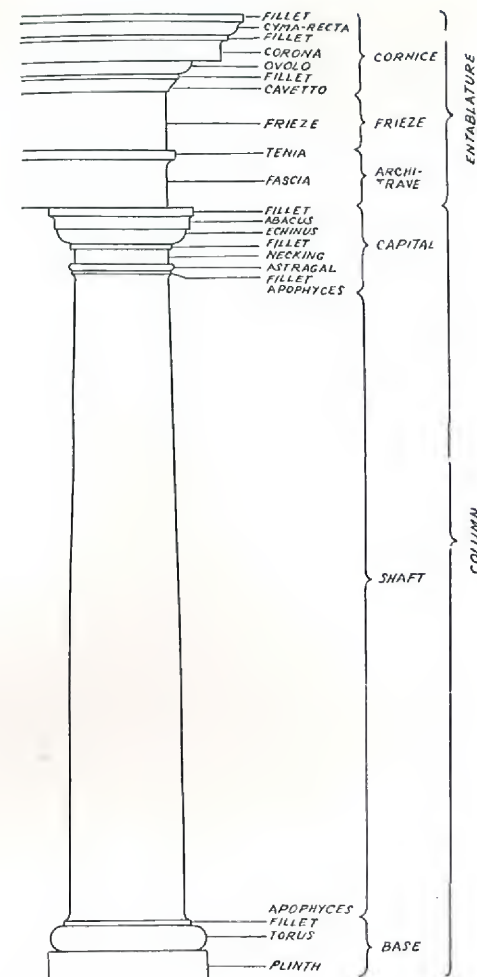
COLONNADE

A—Lintel, B—Soffit

Column, Colum—A vertical shaft or PILLAR; also, any object resembling a column in form and position; figuratively, a prop or support. (See illustration Columns and Capitals)

Conduction—Transmission through or by means of a conductor—water through a pipe; electricity along a wire; heat along a metal bar, one end of which is held in a fire. Transfer of sensible heat through walls and roofs of buildings by conduction may be an important factor. (See Convection, Radiation)

Conservatory—A building for the protection and rearing of tender plants, often attached to a house as an apartment, a greenhouse. Also, a public place of instruction in some branch of



COLUMN

learning or the fine arts, as a conservatory of music. (See illustration Conservatory)

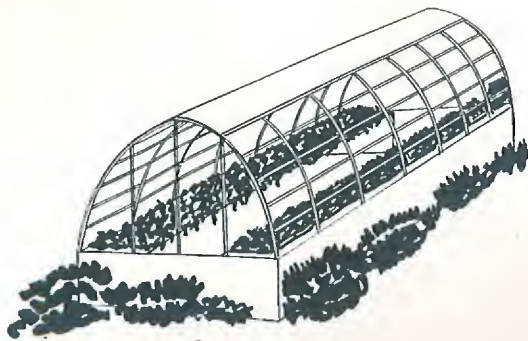
Construction—(See FIREPROOF, FIRE-RESISTANT, MILL, MONOLITHIC, SLOW COMBUSTION.)

Continuous Windows—WINDOWS of steel or wood, designed for use in sides of building, in monitors or SAW-TOOTH ROOF construction. Sometimes equipped for mechanical opening and closing. SASH usually divided in relatively small rectangles for glass.

Contour—The line bounding a figure or body; outline, periphery, configuration.

Convection—The transfer of sensible heat by moving matter such as a stream of hot air which can be felt rising from a hot stove. (See CONDUCTION, RADIATION)

Coping—The capping or covering of a WALL. (See illustration Section Drawing "A")



CONSERVATORY

Corbel—In modern architecture, a short piece of stone or wood projecting from a WALL to form a support, generally ornamented. Brick corbelling is most common.

Core Walls—Similar to CAVITY WALLS, except that the air space is filled with an insulating material. (See Section H-12)

Cornice—The projection at the top of a WALL.

Corridor—Any long passageway in a building.

Counterbalanced Doors—Fire-resisting DOORS made in two sections. On opening, the upper section and lower section are counterbalanced. Used for freight elevator openings, dumbwaiters, or openings in fire walls.

Course—A continued layer of bricks or stones in buildings; the term is also applicable to slates, shingles, glass blocks, Carrara Glass.

Court—An open area behind a house, or in the center of a building and the wings.

Cupola—A small room, either circular or polygonal, constructed on the top of a building. Sometimes called a lantern.

Curtain Wall—A non-bearing WALL between COLUMNS or PIERS.

Dado—A plane, flat, often decorated surface at the base of a WALL, as of a room. One of the faces of a PEDESTAL. WAINSCOT. (See illustration Wainscot)

Dais—A raised platform. ROSTRUM.

Decalcomania, Decal—A print or picture on processed paper to be transferred by gumming to porcelain, glass, furniture, walls or other surfaces for decorative purposes.

Dentil—The cogged or toothed member, common in the bed-mold of a Corinthian entab-

lature, is said to be dentiled, and each cog or tooth is a dentil. (See illustration Moldings)

Design—The plans, ELEVATIONS, SECTIONS, and whatever other DRAWINGS may be necessary for an edifice, or decorative scheme.

Detail—As used by architects, detail means the smaller parts into which a composition may be divided separately shown.

Detention Windows—Fixed steel WINDOWS expressly for institutional use, having small glass openings approximately 6 inches by 9 inches, with ventilators pivoted to open outside fixed steel MUNTINS that serve as barriers when ventilator is open.

Diffusing Lights—See CEILING LIGHTS.

Dome—A CUPOLA or inverted cup on a building. (See illustration Rotunda "B")

Door Frame—The surrounding case into and out of which the door shuts and opens. (See illustration Door "A")

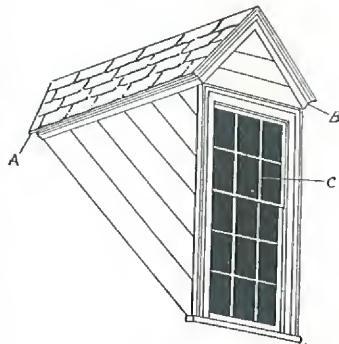


DOOR

A—Door Frame, B—Pediment, C—Threshold

Doors—See COUNTERBALANCED, DOUBLE, DOUBLE-ACTING, DUTCH, EXTRUDED METAL, FOLDING, FRENCH or CASEMENT, HERCULITE, HINGED, HOLLOW-METAL, KALAMEIN, OVER-HEAD, REVOLVING, ROLLING, SHOW CASE, SHOWER-STALL, SINGLE-ACTING, SLIDING, STEEL PLATE, SWINGING, TIN-CLAD, TRAP.

Dormer—A vertical WINDOW in a small gable rising from a sloping ROOF, and lighting usually a bedroom. (See illustration Dormer)



DORMER
A—Verge, B—Eaves,
C—Muntin

Dormitory—A room, suite of rooms, or building used to sleep in.

Double-Acting Doors—HINGED DOORS opening both ways. (See SINGLE-ACTING DOOR)

Double Doors—DOORS hinged at sides, coming together in the center.

Double Glazing—As the name indicates, double glazing embraces two separate pieces of glass, either in one or two SASH units. The additional glazed sash for ordinary windows, STORM SASH.—Double glazed, outside panels of clear or rolled glass for the weather protection of stained or figured glass in church windows are commonly called storm glass.—Double glazed permanently sealed units.

Double Hung Windows—Two sliding SASH in a frame, so arranged as to be raised up and down past each other, with a meeting rail or check rail in the center. Made of wood or metal. Used in all types of buildings. Pivoted sash—same as check rail WINDOWS with a pivoted strip at sides of SASH, permitting sash to slide up and down and pivot horizontally. Used in schools, institutions, etc.

Dovetail—In carpentry and joinery, the method of fastening boards or other timbers together, by letting one piece into another in the form of the expanded tail of a dove.

Dowel—A pin let into two pieces of wood or stone, where they are joined together. A piece of wood

driven into a wall so that other pieces may be nailed to it.

Drawing—See BLUEPRINT, ELEVATION, FLOOR PLANS, FULL SIZE, PERSPECTIVE, RENDERING, SCALE, SECTION, SHOP, TRACING, WORKING.

Drawing-Room—A room appropriated for the reception of company; a room to which company withdraws from the dining room.

Duct—A tube, canal or passage. (See Flue)

Dutch Door—A DOOR which is split horizontally at approximately the middle so that the upper section may be opened while the lower section remains closed.

Eaves—In slating and shingling, the margin or lower part of the slating hanging over the WALL, to throw the water off from the masonry or brickwork. (See illustration Dormer "B")

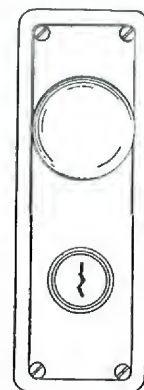
Elevation—A geometrical DRAWING of the external upright parts of a building. (See ORTHOGRAPHY)

Ell—An addition to side of a house, forming the letter L.

Em battlement—An indented BATTLEMENT, PARAPET.

Escalator—A moving stairway, built on the endless chain principle, used in stores, railroad stations, etc.

Escutcheon—The shields used on tombs, in the SPANDRELS of doors, or in string-courses; also, the ornamented plates from the center of which door rings, knockers, etc., are suspended, or which protect the wood of the keyhole from the wear of the key. (See illustration Escutcheon)



ESCUTCHEON

Extruded Metal Doors—DOORS of bronze or aluminum made completely of metal, STILES and rails of extruded metal tubing welded together with extruded MOLDINGS around PANELS, or glass.

Extrusion—The forcing by pressure of metal, usually at high temperature, through a die to form various shapes. This can be done in practically all of the non-ferrous metals and plastics.

Eye Window—A window in the form of a semi-circle. (See illustration Eye Window)



EYE WINDOW

Facade or Face—The whole exterior side of a building that can be seen at one view; strictly speaking, the principal front.

Factory Type Windows—WINDOWS of steel or wood in standard-sized units with openings for standard sizes of glass. Used as single units or multiple units. Often with pivoted ventilators.

Fenestration—The DESIGN or arrangement of the windows of a building.

Finial—The flower, or bunch of flowers, with which a SPIRE, PINNACLE, gablet, CANOPY, etc., generally terminates. (See illustration Finial)



FINIAL

Fireproof Construction — The term fireproof — more properly called fire-resistant—construction applies to all buildings which in all parts carry weights and resist strains with all exterior and interior WALLS and PARTITIONS, stairways and elevator enclosures; consist entirely of incombustible materials; and in which all metallic structural members are protected against the effects of fire by covering materials entirely incombustible. — Reinforced concrete construction is generally considered fireproof.

Firewall—A vertical structural barrier against fire.

Flat Roof—A ROOF that is as nearly horizontal as is practical, allowing for drainage.

Flashings—Pieces of lead, tin, copper, galvanized iron, zinc, roofers' felt or other suitable materials, let into the joints of a WALL so as to lap over GUTTERS or other pieces; also; pieces worked in the slates or shingles around DORMERS, chimneys and any rising part, to prevent leaking.

Fleur-de-lis—The royal insignia of France, much used in decoration; iris.

Flight—A run of steps or stairs from one LANDING to another. (See BALUSTRADE, LANDING)

Floor Plans—Geometrical drawings of the interior DETAILS of a building as distinguished from upright ELEVATION drawings.

Flue—The space or passage in a chimney through which the smoke ascends. Each passage is called a flue, while all together make the chimney.

Flutes—Concave channels. COLUMNS whose shafts are channeled are said to be fluted, and the flutes are collectively called flutings. See illustration Columns and Capitals [Ionic]

Folding Doors—Doors hinged together at their sides to enable them to be folded like an accordion.

Footings—The spreading COURSES at the base or FOUNDATION of a WALL.

Foundation—That part of a building or WALL which is below the surface of the ground.

Foyer—A public room or LOBBY, as in a theater. (See LOBBY)

French or Casement Doors—DOORS with full-length glass panel divided into small LIGHTS with MUNTINS, usually furnished as DOUBLE DOORS in residences, dividing rooms or entrances to PORCHES or terraces. The stiles and top rails of French doors are narrower than ordinary doors.

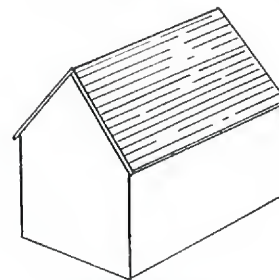
Fresco—The art of painting on plaster; also, a picture so painted.

Fret—Interlaced or perforated ornamental work on wood or stone or in painting; or fretwork.

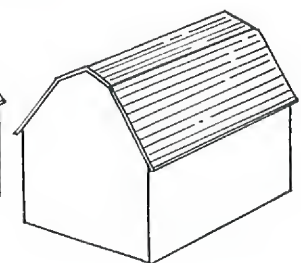
Full Size Drawing—A DRAWING whose measurements are identical with the actual object drawn.

Furrings—Flat pieces of materials used to bring an irregular framing to an even surface, as pieces of wood attached to a surface for lathing.

Gable Roof—A ROOF that has one slope from two sides of a building or enclosure. (See illustration Gable Roof)



GABLE ROOF



GAMBREL ROOF

Gable Window—A term sometimes applied to the large WINDOW under a gable, but more properly to the windows in the gable itself.

Gambrel Roof—A ROOF that has two slopes from two sides of a building or enclosure. (See illustration Gambrel Roof)

Gargoyle or Gargoyle—The carved termination to a spout which conveys the water from the GUTTERS, supposed to be called so from the gurgling noise made by the water passing through it. Gargoyles are mostly grotesque figures.

Girder—A large timber, concrete or steel BEAM, either single or built up, used to support JOISTS or WALLS.

Glazing—The setting of glass in windows or other frames.

Gothic Window—See illustration Gothic Window.

Greenhouse—See Conservatory.

Grille or Grill—A grating or screen of any kind for protecting windows or glass opening in outside doors. A ventilator. (See illustration Grille)



GOthic WINDOW
A—Mullion, B—Splay,
C—Tracery



GRILLE

Grooves—Channels resembling FLUTES, with knife-edge terminations. (See illustration Columns and Capitals [Doric])

Grounds—Pieces of wood embedded in the PLASTERING of WALLS to which skirting and other joiner's work is attached. They are also used to stop the PLASTERING around door and window openings.

Grout—A mortar or cement, thinned to fill joints and cavities of mason-work. A finishing coat for CEILINGS.

Gutter—The channel for carrying off rainwater.

Half-Eye Window—A window in the form of a quarter circle. (See illustration Half-Eye Window)



HALF-EYE WINDOW

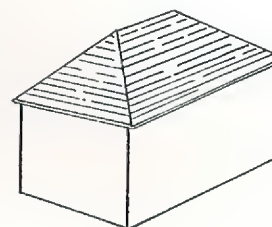
Hard Finish—In PLASTERING, the finish coat of lime-putty and plaster of Paris, to which sometimes marble-dust is added. Keene's cement and lime-putty.

Heat Flow—See CONDUCTION, CONVECTION, RADIATION.

Herculite Door—A DOOR made of one piece of heavy tempered plate glass, having metal fittings attached to accommodate hinges and lock.

Hinged Door—A DOOR suspended by hinges at the side.

Hip-Roof—A ROOF that rises by equally inclined planes from all four sides of a building or enclosure. (See illustration Hip-Roof)



HIP-ROOF

Hoarding—See Barricade.

Hollow Metal Doors—Fire-resistant DOORS formed of sheet steel, reinforced for hinges and lock. Inside may be filled with noncombustible material for sound-deadening and fire-resistance. Made in same types as wood DOORS.

Jamb—The side-post or lining of a doorway or other aperture. The jambs of a window outside the frame are called REVEALS. (See illustration Door "A")

Joist—A small timber to which the boards of a floor or the LATHS of CEILING are nailed. It rests on the WALL or on GIRDERS.

Kalamein Doors—WOOD DOORS covered with lightweight metal. Same types as wood doors. Sometimes classed as fire-resistant when made according to underwriters' specifications.

Keystone—The stone placed in the center of the top of an ARCH.

Kickplate—A plate at the bottom face of a door to protect the door against damage by impact of toes or heels.

Lancet—A high and narrow WINDOW pointed like a lancet, often called a lancet window.

Landing—A platform in a flight of stairs between two stories, the terminating of a stair. (See illustration Balustrade "C")

Lath—A slip of wood, metal or composition material used in slating, tiling and PLASTERING.

Lattice—Any work of wood or metal made by crossing LATHS, rods or bars, and forming a network.

Lavatory—A place for washing the person.

Lean-To—A small building whose rafters pitch or lean against another building, or against a WALL.

Ledge or *Ledgement*—A projection from a plane, as slips or tongues on the side of window and door frames to keep them steady in their places.

Light—A division or space in a SASH for a single PANE of glass; also a pane of glass.

Lintel—The horizontal piece which covers the opening of a door or window. A beam which supports the wall over an opening. (See illustration Section Drawing "C" and Colonnade "A")

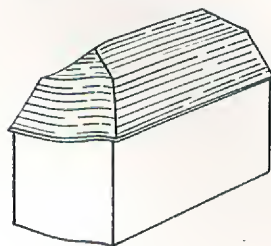
Load-Bearing—Capable of sustaining a burden of weight.

Lobby—An open space surrounding a range of chambers, or seats in a theater, a small hall or waiting room. (See FOYER)

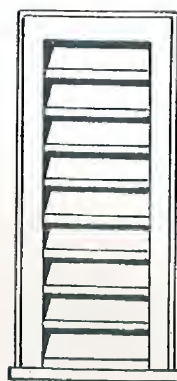
Loge—A theater box; booth, stall.

Loggia—An outside gallery or PORTICO above the ground, and contained within the building.

Louver or *Louvre*—A WINDOW designed for ventilation, having slats (louver boards), sloped to keep out rain. (See illustration Louver)



MANSARD ROOF



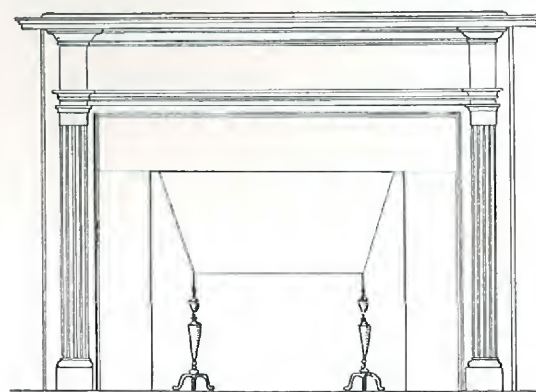
LOUVER

Lucarne—A DORMER or gablet WINDOW, also a small WINDOW or LIGHT in a SPIRE.

Mansard Roof—A ROOF that has two slopes from all four sides of a building. (See illustration Mansard Roof)

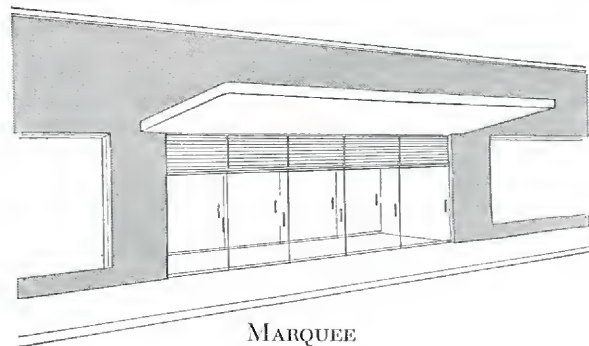
Mansion—A large or handsome dwelling; specifically, the house of the lord of a manor; a manor-house.

Mantel—The work over a fireplace in front of a chimney, especially a shelf, usually ornamented, above the fireplace. (See illustration Mantel)



MANTEL

Marquee or *Marquise*—An awning for a window; an ornamental hood over a house-door. See CANOPY. (See illustration Marquee)



MARQUEE

Marquetry—Inlaid work of fine hard pieces of wood of different colors, also of shells, ivory and the like. (See PARQUETRY)

Mastic Cement—Any of various pasty cements, usually bituminous.

Mausoleum—A magnificent tomb or sumptuous sepulchral monument.

Medallion—Any circular tablet on which are embossed figures or busts.

Meeting Rail Windows—See DOUBLE HUNG WINDOWS.

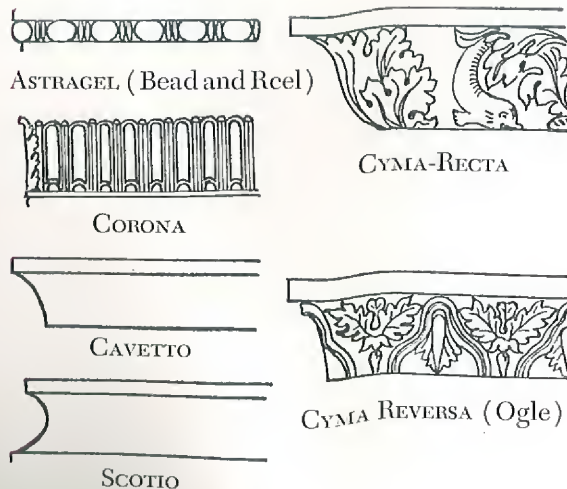
Mezzanine—A balcony or intermediate level overlooking a room area having a lofty CEILING.

Mill Construction—Slow combustion buildings. Mill CONSTRUCTION consists in so disposing the timbers and planks in heavy solid masses as to expose the least projections to fire, and that when fire occurs may be readily reached by water from sprinklers or hose. The purpose of mill construction is to reduce the fire-risk to its lowest point at a reduction of cost of fireproof construction. Such buildings are distinguished by the use of heavy timbers for PILLARS and JOISTS with the exterior WALLS of stone, concrete or brick. Sometimes in combination with FIREPROOF CONSTRUCTION, where a part of the building is mill construction.

Minaret—Turkish: a circular TURRET rising by different stages or divisions, each of which has a balcony.

Miter—A MOLDING returned upon itself at an angle is said to miter. In joinery, the ends of any two pieces of wood of corresponding form, cut off at 45 degrees, which necessarily abut upon one another so as to form a right angle, or which abut at any other angle so that the pattern continues, are said to miter. On glass, a V or angle cutting is a miter.

Molding or Moulding—A more or less ornamental strip on some part of a structure. A CORNICE or other depressed or projecting decorative member on a surface or angle of any part of a building. (See illustration Moldings, below)



OVOLO
Egg and Tongue Enrichment

DENTILS

Monolith—A single piece or block of stone fashioned or placed by art, particularly one notable for its size; any structure or sculpture in stone formed of a single piece.

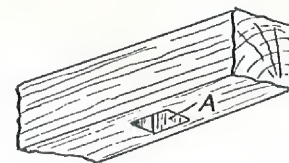
Monolithic Construction—The term commonly applied to solid concrete or reinforced concrete or all-stone buildings.

Mop Board or Base Board—A board skirting the lower edge of a WALL of a room. (See illustration Balustrade "B")

Mortise—A space hollowed out, as in a timber, to receive a TENON or the like. (See illustration Mortise and Tenon "A")

Mosaic—Pictorial representations, or ornaments, formed of small pieces of stone, marble or enamel of various colors.

Mullion, Munion — A post dividing window openings, or a division piece between windows. (See illustration Gothic Window "A")



Muntin — A division piece or bar between window LIGHTS. (See illustration Dormer "C")



MORTISE
A—Mortise, B—Tenon

Museum—A place devoted to works of nature, art curiosities, etc.; also, the collection itself.

Nave—The central part between the ARCHES of a church, which formerly was separated from a chancel or choir by a screen. The seating area for worshippers. It is so called from its fancied resemblance to a ship. (See illustration Church Floor Plan "C")

Newel—A post from which the steps of a winding stairway radiate.

Newel-Post—A post at the end of a stair or hand-rail. (See illustration Balustrade "D")

Niche—A recess sunk in a WALL, generally for the reception of a statue. (See illustration NICHE)

Non-Load-Bearing Wall—A WALL which supports no other load except its own weight. Curtain wall.

Obelisk—A square shaft with pyramidal top, usually monumental.

Offsets—When the face of a WALL is not one continued surface, but sets in by horizontal jogs, as the wall grows, higher and thinner, the jogs are called offsets.

Ogee—The name applied to a MOLDING, partly a hollow and partly a round, and derived no doubt from its resemblance to an O placed over a G.

Orchestra—In modern theaters, where the musicians sit.

Oriel Window—A WINDOW built out from a WALL and resting on a BRACKET or like support, distinguished from a BAY WINDOW. (See illustration Oriel Window)

Orientation—Literally, defined as describing the position of a building with reference to the sun or east. Sequence of ideas to adapt the DESIGN and architectural DETAIL to facilitate the utmost usefulness of the structure.

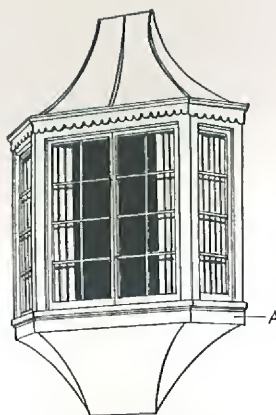
Orthography—A geometrical ELEVATION of a building or other object in which it is represented as it actually exists or may exist, and not PERSPECTIVELY, or as it would appear.

Overhead and Sliding Doors—Wood, wood metal-covered, or all-metal DOORS with solid PANELS or glazed panels. Overhead roll-up doors are divided into sections horizontally to follow CONTOUR of curved guides. (See ROLLING DOORS)

Ovolo or Quarter-Round—convex MOLDING. (See illustration Moldings)



NICHE



ORIEL WINDOW

A—Apron

Pane—Probably a diminutive of panneau, a term applied to the different pieces of glass in a window; same as LIGHT.

Panel—Properly, a piece of wood framed within four other pieces of wood, as in the STILES and rails of a door, filling up the aperture, but often applied both to the whole square frame and the sinking itself; also to the ranges of sunken compartments in WAINSCOTING, CORNICES, CORBEL tables, groined VAULTS, CEILINGS, etc. (See illustration Wainscot "A")

Parapet—A dwarf WALL along the edge of a ROOF. (See illustration Section Drawing "D")

Parquetry—Wooden mosaic for furniture or floors. (See MARQUETRY)

Partitions—Interior walls or other barrier dividing one part of an interior space from another. (See WALLS)

Party Walls—PARTITIONS of brick or stone between buildings on two adjoining properties. A wall common to two buildings.

Pedestal—A base or support of a COLUMN, PILLAR, statue, etc. (See COLUMN)

Pediment—A broad triangular space, as above a PORTICO or door. (See illustration Door "B")

Penthouse—An independent room or enclosure erected on the ROOF of a building.

Peristyle—A range of COLUMNS encircling an edifice.



PIER GLASS

Perspective Drawing—The art of making such a representation of an object upon a plane surface as shall present precisely the same appearance that the object itself would to the eye situated at a particular point.

Pier Glass—A large high mirror intended to stand against a **PIER** and thus fill the space between two openings in the **WALL**. (See illustration Pier Glass)

Piers—The solid parts of a **WALL** between windows, and between voids generally.

Pilasters—Vertical shafts, with **CAPITAL** and base, attached to a **WALL** and projecting from the wall about a fourth or a sixth part of their breadth. (See illustration Pilasters and Spandrel "B")

Pillar—A firm, upright separate support; **COLUMN**. Something resembling a **COLUMN** in form or use. (See illustration Column)

Pinnacle—A small **TURRET** or tall ornament, as on **PARAPET**.

Pivoted Sash or Windows—See **DOUBLE-HUNG WINDOWS**.

Plastering—See **BROWN COAT**, **HARD FINISH**, **PUTTY COAT**, **SAND FINISH**, **SCAGLIOLA**, **SCRATCH COAT**, **SKIM COAT**, **WHITE COAT**.

Plate Rail—A shelf-like **MOLDING** around a room, for holding ornamental plates or bric-a-brac.

Plinth—The square block at the base of a **COLUMN** or **PEDESTAL**. (See **COLUMN**)

Plumb—Perpendicular; that is, standing according to a plumb line, as the post of a house or **WALL** is plumb.

Ply—Used to denote the number of thicknesses, as 3-ply, 4-ply, etc.

Porch—A covered structure forming an entrance to a building; outside and with a separate **ROOF**.

Portal—A passage for entrance; entranceway; especially, one that is grand and imposing.

Porte-Cochere—A covered areaway by which a

vehicle may be driven under or through a portion of a building.

Portico—An open space before the door or other entrance to any building, fronted with **COLUMNS**, **STOA**.

Portiere—A curtain, or the like, for use in a doorway, either instead of a door or as an ornament.

Profile—An outline or **CONTOUR**; a **DRAWING** in outline, as in vertical section or the like.

Projected Windows—**WINDOWS** of steel or wood, divided horizontally for glass, having part or all units pivoted at top or bottom so that they open to the outside or inside. Sometimes called **AWNING WINDOWS** when the **SASH** are pivoted at the top and open to the outside.

Proscenium—In a modern theater or similar building, that part of the stage between the curtain or drop-scene and the **ORCHESTRA**, sometimes including the curtain and its **ARCH**.

Protection or Security Windows—Steel **WINDOWS** for commercial buildings, using the general pattern of **DETENTION WINDOWS** with larger glass openings—approximately 6 inches by 18 inches.

Purlins—Those pieces of timbers which support the rafters to prevent them from sinking. Horizontal timbers extending from end to end of a building or roof across and under the rafters to support them.

Putty Coat—In **PLASTERING**, the third or finish coat. **SKIM COAT**, **WHITE COAT**.

Push Bars—Bars, handles on a door at hand level to take the impact or thrust exerted to open a door, sometimes operating the latch.

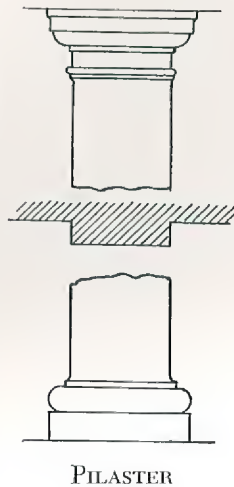
Push Plates—Plates on a door at hand level to take the impact or thrust exerted to open a door, and to protect the door against damage.

Pyramid—A solid structure with a square base, and with triangular sides meeting in an apex.

Quadrangle—A square or quadrangular **COURT** surrounded by buildings.

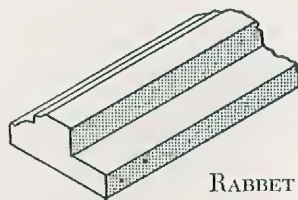
Quarry—A **PANE** of glass cut in a diamond or lozenge form.

Quarter-Round—See **OVOLO**. (See illustration Moldings)



Rabbet or Rebate—A recess in or near the edge of another piece. (See illustration Rabbet)

Rabbet-Joint — A joint between two edges, as of timbers, each of which is partly cut away so that their faces are flush.



RABBET

Radiation—The transfer of energy directly through space. For example, the passage of heat through the vacuum of a lamp bulb from the heated filament. Also, the radiation or heating units in the sense of square feet of radiation. (See CONDUCTION, CONVECTION)

Ramp—An inclined walk or inclined driveway.

Recess—A depth of some inches in the thickness of a WALL as a NICHE.

Refectory—A room for eating, especially in a religious house or college, a hall set apart for meals.

Rendering—In DRAWING, finishing a PERSPECTIVE DRAWING in ink or color, to bring out the spirit and effect of the DESIGN.

Reredos, Dorsal or Dossel—The screen or other ornamental work at the back of an altar.

Return—The continuation of a MOLDING, projection, etc., in another or opposite direction.

Reveal—The two vertical sides of an aperture, between the front of a WALL and the window or door frame. (See illustration Section Drawing "B")

Revolving Doors—A combination or set of 4 Doors joined together at right angles in the form of a cross, supported on a central pivot, to revolve inside a circular enclosure or side wings.

Ridge—The top of a ROOF which rises to an acute angle.

Ridge-Pole—The highest horizontal timber in a ROOF.

Riser—The vertical board under the tread in stairs. (See illustration Balustrade "E")

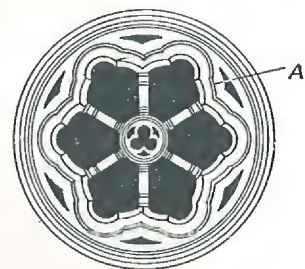
Rolling Doors—DOORS made of interlocking slat-plates of galvanized steel, mounted on an overhead shaft, to be rolled up like a window shade.

Used in commercial and industrial buildings. (See OVERHEAD DOORS)

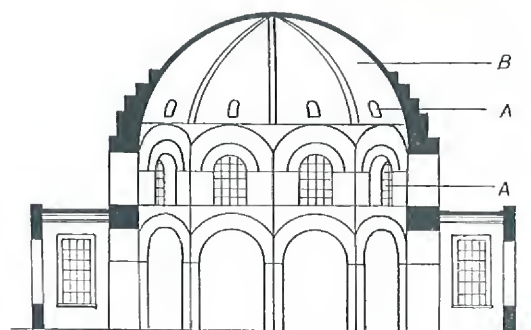
Roman Mosaics—Glazed enameled TILES of baked vitreous clay similar to CERAMIC TILES, for WAINSCOTS and MANTEL work.

Roof—The covering or upper part of a building or enclosure. (See FLAT, GABLE, GAM-BREL, HIP, MAN-SARD, SHED, SAW-TOOTH)

Rose Window — A name given to a circular WINDOW with radiating TRACERY, called also wheel window. (See illustration Rose Window)



ROSE WINDOW
A—Tracery

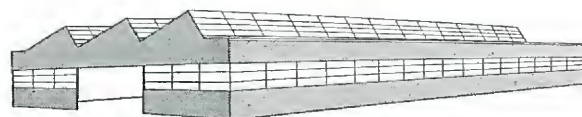


ROTUNDA
A—Clerestory, B—Dome

Rostrum—An elevated platform from which a speaker addresses an audience. DAIS.

Rotunda—A circular building or an interior hall, surmounted with a DOME. (See illustration Rotunda)

Rubble Work—Masonry of rough, undressed stones.



SAW-TOOTH ROOF

Rustic or Rock Work—A mode of building in imitation of nature.

Salient—A projection.

Salon—A spacious and elegant apartment for the reception of company, or for state purposes, or for the reception of paintings.

Sanatorium—See *SANITARIUM*.

Sand Finish—In *PLASTERING*, a rough surface finish coat resembling coarse sandpaper.

Sanitarium — A place devoted to the preservation or restoration of health through hygienic methods. Sanatorium.

Sarcophagus — A tomb or coffin made of stone, and intended to contain the body.

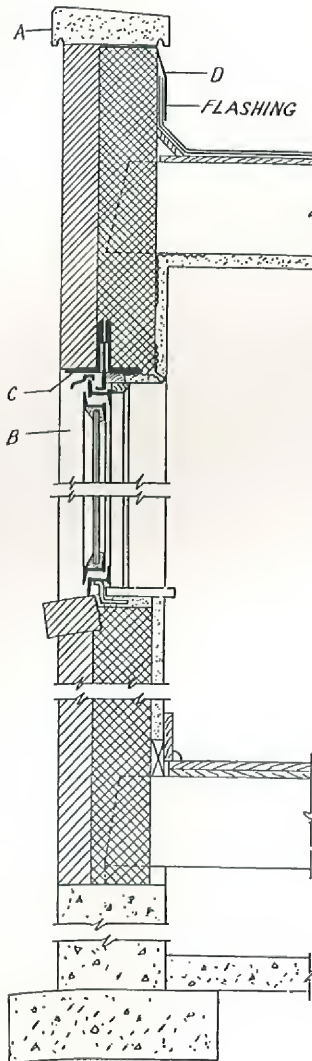
Sash — The framework which holds the glass in a window.

Saw-Tooth—An element of plan or *PROFILE* having the *CONTOUR* of the tooth of a saw.

Saw-Tooth Roof — A *ROOF* whose *CONTOUR* is similar to the teeth in a saw. (See illustration Saw-Tooth Roof)

Scagliola — Hard, polished plaster-work imitating marble, granite or other stone, made of powdered gypsum and glue colored in various ways.

Scale Drawing—A *DRAWING* whose measurements are relative to and proportional to the actual object drawn.



SECTION DRAWING

A—Coping, B—Reveal,
C—Lintel, D—Parapet

Scantling—A timber less than 5 inches in breadth and thickness, used for studding, etc.; also, such timbers collectively.

Scratch Coat—The first coat of *PLASTER*, which is scratched to afford a bond for the second coat.

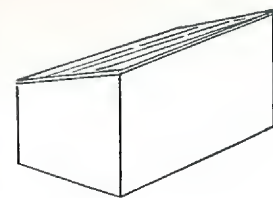
Section Drawing—A *DRAWING* showing the internal construction and dimensions of the various parts of a structure. It supposes the structure to be cut through entirely, so as to exhibit the *WALLS*, the heights of the internal doors and other apertures, the heights of the stories, thicknesses of the floors, etc. (See illustration Section Drawing)

Security Windows—See *PROTECTION WINDOWS*.

Septic Tank—For sewage disposal, usually in a rural or rustic location where there is no community sewer system.

Sheathing—The first covering of boards or other material on the outside walls of a house—the material so used.

Shed Roof — A *ROOF* with one slope from a higher *WALL* to a lower wall. See illustration Shed Roof)



SHED ROOF

Shop Drawing — A *DRAWING* made expressly for fabricating an element or an object.

Shore—A piece of timber placed in an oblique direction to support a building or *WALL* temporarily while it is being repaired or altered.

Show Case Doors—All-glass *SLIDING DOORS* on track to provide for opening and closing. Glass *DOORS* with metal frame, hinges and lock for outdoor show cases.

Shower Stall Doors—Metal frame with heavy glass panel or *HERCULITE* Glass with metal frame and hinges for shower compartment.

Sills—The term is most frequently applied to those pieces of timber, stone or metal at the bottom of doors or windows.

Single-Acting Door—A *HINGED DOOR* opening one way only. (See *DOUBLE-ACTING DOOR*)

Skim Coat—In PLASTERING, the third or finish coat. WHITE COAT, PUTTY COAT.

Skylight—A WINDOW in a ROOF or CEILING.

Sleeper—A piece of timber laid on the ground to receive floor JOISTS.

Sliding Doors—Doors mounted on a track below or above to enable door to move sidewise. (See OVERHEAD DOORS)

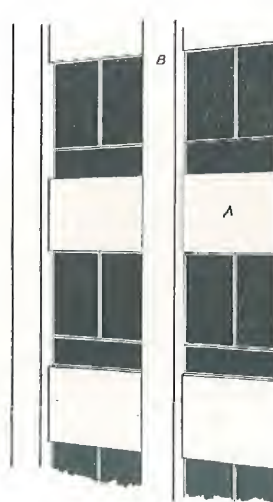
Slow Combustion—See MILL CONSTRUCTION.

Soffit—The under side of a staircase, entablature, LINTEL, ARCHWAY or CORNICE. A CEILING. (See illustration Colonnade "B")

Solarium—A place or room open to the sun's rays, as in a SANITARIUM.

Spall—Bad or broken brick; stone flakes; glass chips.

Spandrel or Spandril—The triangular space between the shoulder of an ARCH and the rectangular figure formed by the MOLDINGS, etc., over it; also, the space between the shoulders of two adjoining ARCHES. In WALLS, the space between the SILL of an upper window and the head of a lower window. (See illustration Spandrel "A")



SPANDREL

A—Spandrel, B—Pilaster

Specification—Architect's. The designation of the kind, quality, and quantity of work and material to go in a building, in conjunction with the WORKING DRAWINGS.

Spire—The tapering or pyramidal ROOF of a tower; a PINNACLE; also a Steeple. (See illustration Steeple "B")

Splay—A slanted surface or beveled edge, as of the sides of a doorway or window, or of a JOIST. (See illustration Gothic Window "B")

Steel Plate Doors—

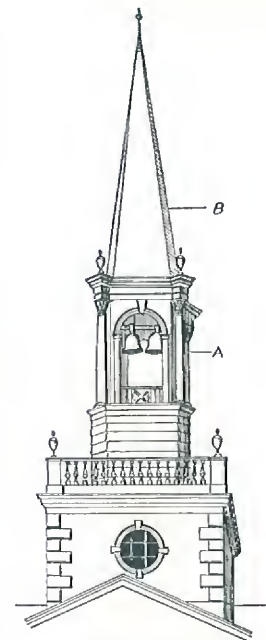
DOORS made of steel plates, reinforced on one side with angle irons. Adapted for use as fire doors, elevators, vaults, sidewalk, etc.

Steeple—A general name for the whole arrangement of tower, BELFRY, SPIRE, etc. (See illustration Steeple)

Stile—The upright piece in framing or PANELING, as on a door.

Stoa—A PORTICO.

Stoop—A seat before the door; often a PORCH with a BALUSTRADE and seats on the sides.



STEEPLE

A—Belfry, B—Spire

Storm Windows or Storm Sash—An extra outside removable glazed SASH applied to a regular WINDOW for added weather protection.

Suspended or Hung Ceiling—A CEILING suspended from above; to make a proper finish in the room, provide insulation, or service space.

Structural Glass—Usually opaque glass used principally in the facings of walls or as free-standing partitions—frequently heavy glass, clear or opaque, as used in floors.

Swinging Door—A DOOR controlled by a spring hinge which is self-closing. (See SINGLE-ACTING, DOUBLE-ACTING DOORS)

Tapestry—A kind of woven hanging of wool or silk, ornamented with figures, and used to cover and adorn the WALLS of rooms.

Template or Templet—A pattern or guide, as of wood or metal, adapted to the purpose of shaping something.

Tenon—A projection on the end of a timber for inserting in a socket to form a joint. (See illustration Mortise and Tenon "B")

Terrazzo—A floor surfacing, usually over concrete, consisting of cement impregnated with crushed marble chips of varied colors, rolled and rubbed to a smooth, even surface.

Threshold—The plank, stone, or the like, placed beneath the door of a building; hence an entrance. (See illustration Door "C")

Tiles — Flat or corrugated rectangle-shaped pieces of clay burned in kilns, for ROOFS. Also, flat pieces of fired clay, either plain or ornamented, glazed or unglazed, for floors, WAINSCOTING, WALLS, etc. Small square or rectangular pieces of marble or Carrara Glass are also called tiles.

Tin-Clad Fire Doors—Wood Doors completely covered with sheet tin to meet rules of fire underwriters.

Tracery—The ornamental filling-in of the heads of windows, PANELS, circular windows, etc. (See illustration Gothic Window "C" and Rose Window "A")

Tracing Drawing—A DRAWING made on a transparent paper or treated linen for the purpose of reproduction.

Transept—That portion of a church which passes transversely between the NAVE and choir, at right angles, and so forms a cross on the plan. (See illustration Church Floor Plan "B")

Transom—A horizontal piece framed across an opening; hence a window or panel above such a bar, especially a small window above a door.

Trap Door—DOOR in floor or CEILING.

Tread—The horizontal part of a step of a stair. (See illustration Balustrade "F")

Trellis—LATTICE-work of metal or wood for vines to run on. (See LATTICE)

Tuck-Pointing—Marking the joints of brickwork with a narrow parallel ridge of fine putty, mortar, etc.

Turret—A small tower, especially at the angles of larger buildings, sometimes overhanging and built on CORBELS, and sometimes rising from the ground.

Valley—The internal angle formed by two inclined sides of a ROOF.

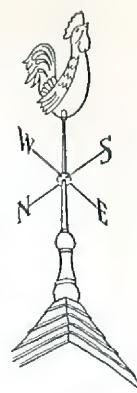
Valley Rafters—Those which are disposed in the internal angle of a ROOF to form the VALLEYS.

Van Dyke—Similar to Blueprint, in Brown and White.

Vane—The weathercock on a STEEPLE. (See illustration Vane)

Vault—An arched CEILING or ROOF. A vault is, indeed, a laterally conjoined series of ARCHES.

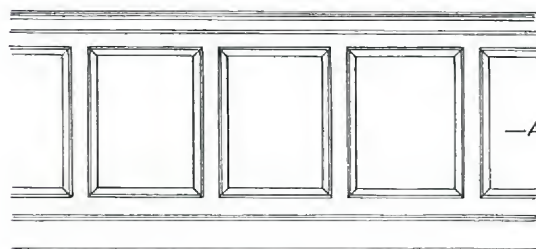
Verge—The edge of the tiling, slate or shingles, projecting over the gable of a ROOF, that on the horizontal portion being called the EAVES. (See illustration Dormer "A")



VANE

Volute—A spiral scroll-like ornament, as in Corinthian CAPITALS. A scroll.

Wainscot—The lining of WALLS, generally in PANELS. See DADO. (See illustration Wainscot)

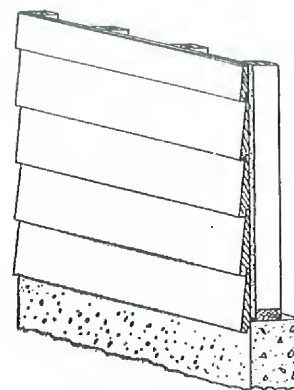


WAINSCOT

A—Panel

Walls—The vertical confinements of an enclosure, usually the exterior enclosures of a building. (See BEARING, CURTAIN, FIRE, LOAD-BEARING, NON-LOAD-BEARING, PARTITIONS, PARTY)

Weather Boarding — Boards lapped over each other to prevent rain, etc., from passing through. CLAPBOARD. (See illustration Weather Boarding)



WEATHER BOARDING

Weather Vane — See VANE.

Weathering — A slight fall on the top of CORNICES, WINDOW SILLS, etc., to throw off the rain.

Well—The vertical opening contained within a winding staircase. A vertical compartment descending through floors, or a deep enclosed space in a building as for light or ventilation; as an air-well, an elevator-well.

White Coat—In PLASTERING, the third or finish coat. SKIM COAT, PUTTY COAT.

Windows—See AWNING, BAY, CASEMENT, CIRCLE, CLERESTORY, CONTINUOUS, DETENTION, DIFFUSING (CEILING), DORMER, DOUBLE GLAZED,

DOUBLE HUNG (CHECK), DOUBLE HUNG (PIVOT), EYE, FACTORY TYPE, FENESTRATION, GABLE, GOTHIC, HALF-EYE, LANCET, LOUVER, LUCARNE, ORIEL, PROJECTED, ROSE, SECURITY (PROTECTION), STORM, TRACERY.

Wing—A side building less than the main building.

Working Drawing—A DRAWING which correlates the various elements making up the whole. That from which the building will be constructed, as contrasted with preliminary drawings or details.

Glossary

abrasion—The rubbing away of material, as in grinding.

absorb—To become permeated with a liquid or gas, as a sponge absorbs water.

abutting—Where two materials meet edge to edge or end to end—immediately adjoining each other.

accelerating—Increasing speed. Acceleration may be constant or variable.

acid—Usually one of the mineral acids: sulphuric, nitric, hydrochloric, etc. Any material having a hydrogen ion (pH) value of less than 7. Imparting a sour taste. Usually very corrosive, especially hydrofluoric.

actinic—Any rays of radiant energy having photochemical effect. Often erroneously applied to the ultra-violet portion of the spectrum, only.

adhere—To stick to, as a postage stamp adheres to an envelope.

adjunct—An aiding or participating part. Not necessarily integral with the part assisted.

adsorb—Roughly speaking, to hold some liquid or gas as a molecular film on the surface of a solid.

adverse—Unfavorable, contrary to, undesired.

air-foil—The streamlining of a surface to reduce friction between that surface and air.

align—To bring into line.

alloy—A homogeneous solid solution of two or more metals in each other.

alpha—The first letter in the Greek alphabet. Specifically, the longest wave length, slowest moving, least penetrating of the Radium emanations; the particles of alpha rays are supposed to be Helium gas.

amalgamation—The complete assimilation of one material into another. Usually the alloy of Mercury with another metal.

amethyst—A purple color characteristic of the semi-precious amethyst gem. A quartz probably colored by manganese.

amorphous—Being without crystalline structure.

anachronism—Out of its proper time or era.

analogous—Exactly similar to.

analyzer—An instrument for examining the extraordinary ray of polarized light after it has passed through some other intermediate polarizing material.

angle of repose—The angle with the horizontal taken by the face of a pile of material at which further slippage of the pile ceases.

Angstrom—A unit of measure of the wave lengths of radiant energy, being one-tenth of a millimicron.

annealing—Removing strain from a material by a heat treatment which permits intermolecular arrangement within the body of the material until strains are relieved.

anthracite breeze—A very fine anthracite coal dust.

appurtenances—Items appertaining to or belonging to a person, process or machine.

aqua regia—An exceedingly corrosive mixture of nitric acid and hydrochloric acid in approximately equal parts. Solvent for gold, platinum and other rare metals.

aquarium—A container of almost any size for the culture and display of aquatic life forms.

arris—A narrow, smooth bevel on the edge of a plate of glass.

artisan—A workman, particularly a skilled workman.

ashlar—A small, thin, squared and dressed material for facing a wall, particularly pieces of Carrara Glass 8" x 8" up to 24" x 24".

astronomer—A student of the science of astronomy—the study of the stars.

astuteness—Brilliance of mind, exactness of understanding.

atomic—Of the size of an atom. The smallest reaction unit of a chemical element.

augmented—Increased.

autoclave—A tank or container. The internal pressure and temperature may be controlled at will. Used principally to simultaneously apply heat and pressure.

auxiliary—Assisting or helping.

back bars—The fixtures and walls back of a bar.

bacteria—Germs, microscopic organisms causing disease.

baffle—A wall against which the fires play and by which the direction of flames is changed or altered. A barrier.

bait—Specifically the iron bar lowered into a bath of molten glass to start the draw of a flat drawn sheet, after the glass has frozen around it.

ballast—Any heavy substance used to maintain stability and equilibrium.

band courses—Rows of panels with the design running approximately vertical.

barrier—An obstruction, or fence.

basalts—Dark and hard species of volcanic glass.

base—The main or chief ingredient of a mixture. An element which combines with an acid to form a salt.

bas-relief—Sculpture in low relief; slightly raised work.

batch—The mixture of raw materials which by fusion is converted into glass.

bay—One of the main divisions of any structure.

beaker—A deep, open-mouthed, thin vessel with a projecting lip for pouring.

bend—A curve of glass.

beta—Second letter of the Greek alphabet used to distinguish a specific radium emanation.

bevel—The slant or inclination of the edge of a piece of glass.

bifocal—A glass lens having two focus points.

bleed—To diffuse or run when wet.

blemish—A defect or flaw.

blowpipe—A long wrought iron tube, on the end of which the workman gathers a gob of glass and through which he blows to expand or shape the glass.

bolelection—That portion of a group of moldings which projects beyond the general surface of the panel.

bombsight—An apparatus for determining the direction of flight of an aerial bomb.

bond coat—The initial material used to solidify the surface of a wall and insure security of the paint film, etc.

bracket—A designated group of similar materials.

breeching—A fastening.

breeze—See anthracite breeze.

brine—Water strongly impregnated with salt.

buckstay—Either of two connected girders used one on each side of the masonry structure of a furnace or flue to take the thrust of the arch.

buffer—Anything serving to deaden the shock or bear the brunt of opposing forces.

burn—Small projections or indentations on the surface of glass, appearing as an area of small specks, together with some destruction of the surface polish; resulting from contact, while still very hot, with dust, sand, etc.

burnish—To polish.

butt-joining—Laying two pieces of material together, to meet edge to edge.

by-product—A secondary or additional product.

calcined—Reduced to a powder by the action of heat.

calibrate—To determine the graduation of, as of various standards or graduated instruments.

calk, caulk—To drive tarred oakum into the seams or joints to prevent leaking.

cant strip—A beveled molding.

capillarity—The peculiar action by which the surface of a liquid, where it is in contact with a solid, is elevated or depressed.

- carbon*—An elementary substance occurring native as the diamond, graphite—in glass practice, usually derived from coal.
- carborundum*—A beautiful crystalline compound consisting of carbon and silicon in combination as silicon carbide.
- cased*—Covered with a layer or layers of different glass. See flashed.
- casting*—Pouring molten material into a mold or form—glass poured onto a table to be rolled into a sheet.
- cater*—To satisfy the demand for.
- cathode*—The negative terminal of an electric source.
- caustic alkali*—An alkaline substance producing corrosion by chemical action—Sodium hydroxide, potassium hydroxide, quick lime, etc.
- cellulated*—Consisting of cells.
- ceramic*—Articles formed of silicates which have been subjected to fire.
- channels*—Top or bottom fitting of a Herculite Door to hold hinges and other appliances.
- charge*—The quantity of material which any apparatus is intended to receive and fitted to hold.
- chip*—To remove the smooth surface of a sheet of glass by the action of glue, producing a fern-like non-repetitive design.
- chromic*—Pertaining to or obtained from, chromium.
- chuck*—A device for holding the work.
- cinematograph*—The original name of "the movies."
- cleavage*—The lines or planes along which crystalline materials will normally separate into smaller parts.
- coefficient*—A number expressing the amount of some change.
- colloidal*—Resembling glue or jelly—very finely divided material.
- colorant*—Material used to produce color.
- colorfuse*—Colors baked into the surface of a sandblasted design.
- combustible*—Apt to catch fire.
- component*—An ingredient.
- compound*—A chemical combination of different elements, ingredients, or parts.
- compressible*—Capable of being reduced in volume by pressure.
- concave*—The interior face of a curved surface; opposite to convex.
- conchoidal*—Shell-like in appearance.
- concomitant*—Accompanying, collaterally connected with.
- conductivity*—Quality or power of receiving and transmitting.
- configuration*—The uneven design impressed upon the surface of glass; surface contours of the earth.
- conglomeration*—A mixed coherent mass.
- conical*—Round and tapering to a point, cone shaped.
- consummate*—With perfect ease; to accomplish.
- contamination*—Impurities derived from containers or other equipment.
- convection*—The process of conveying or transmitting resulting from differences in temperature.
- converge*—To tend to one point or line.
- converse*—Reversed in order or relation.
- convex*—The outer surface of a curve; opposite to concave.
- coping*—The highest or covering course of a wall, often with a sloping top to carry off water.
- cord*—Sometimes known as string; the tail left by an uncompletely assimilated bit of batch material in the body of the glass usually in conjunction with a stone.
- corporate*—Combined into one body by legal enactment.
- corrosion*—A destruction or eating away of a substance by a chemical process.
- countercurrent*—Running in an opposite direction.
- counterpart*—A copy; duplicate.

cove—A concave molding—a recess to receive electric lighting equipment.

cradle—A box or crate for the temporary handling of a piece of glass or other material.

crown glass—Any of the usual soda-lime-silica glasses which may be modified by the addition of other materials for ophthalmic or optical purposes.

crucible—A vessel or melting pot of some refractory material.

crystal—A body formed by the solidification, usually from a solution, of a chemical element or compound whose surface is bounded by planes symmetrically arranged.

cubical—Three-dimensional.

cullet—Broken or refuse glass for remelting.

curative—Tending to cure.

deckle—A ragged, uneven or rough edge.

decolorized—Deprived of color.

deflect—To turn aside.

dehydration—Rendering free from water.

demarcation—Separation; distinction.

desiccant—A drying material.

deviation—Digression; divergence.

devitrify—To deprive of glass-like luster or transparency—separation of glass components in a crystalline condition.

devoid—Not in possession—without.

dexterity—Skill and ease in using the hands.

dial—The graduated face for measuring.

diameter—Any chord passing through the center of a circle.

die cutting—Cutting or stamping with an impressed metal block or plate.

dielectric—An insulator.

diffuse—To spread; disseminate.

disk, disc—A flat circular plate.

disseminate—To spread or extend by dispersion.

dissipation—Dissolution; disintegration.

diversity—Distinction; separate.

dolomite—A carbonate of calcium and magnesium, occurring in extensive beds as a compact dolomitic limestone.

dome—A cap-like formation.

dredged—Excavated.

drive shaft—A cylindrical bar used to impart motion.

drop well—A type of railroad car especially designed for the transportation of Jumbo size glasses.

dross—Waste matter.

duct—A tube or vessel to maintain direction.

efficacy—Efficient action.

efflorescence—A covering or crust, bloom.

electrolyte—A compound subjected to decomposition by an electric current—a liquid conductor of electricity, usually slightly acid in character.

electronic—Of or pertaining to an electron.

element—One of the relatively simple forms or units which enter variously into a complex substance.

elongate—To lengthen.

emanate—To issue forth from a source.

embellishment—Decoration

emery—A dark granular variety of corundum used for polishing.

encompass—To surround.

entity—Being; existence.

equanimity—Poise, composure.

erosion—Wearing away.

espouse—To adopt; to pledge.

excrescences—Growths or protrusions from.

extraneous—Not belonging to.

extrusion—Expulsion—forcing out.

fabricate—To frame; construct; build.

facade—The front of a building.

facia—A plate or tablet over the front of a shop, bearing the name of the merchant, etc.; the front elevations of buildings.

fastness—Remote and exceedingly difficult of access.

fatigue—Deterioration of a member in a structure due to a continued repetition of stress.

feasible—Practicable.

feldspar—A group of minerals, closely related in crystalline form, and all silicates of aluminum with either potassium, sodium, calcium, or barium.

ferrous—Pertaining to, or derived from, iron—bivalent iron.

fiber—A thread or threadlike structure or object.

filament—A separate fiber.

fillet—A curved surface or line used to blend two other surfaces or lines into each other.

filter—Any substance which selectively permits or bars the passage of other substances.

fire opal—An opal of varying color which does not completely diffuse the outline of a light source.

fitting—Auxiliary parts.

flaking—In glass cutting, small chips leaving the sides of a cut score when the wheel is pressed too strongly or is improperly sharpened.

flanged—Spread out.

flare—A knife or razor-edge left near the face of a piece of glass when the cut does not follow vertically through the plate.

flashed—Glass which has been reheated to develop the color. See eased.

flask—A small bottle-shaped vessel for holding fluids.

flint glass—Has two separate and distinct meanings: the proper meaning applies to optical or ophthalmic glass containing lead. The term is erroneously applied in the flat glass industry to clear, seemingly water white glasses which ordinarily do not contain any lead.

flotation—The process of separation at different levels, of particles of fixed size, depending upon the velocity of the supporting fluid.

fluorescence—That property which some bodies have of converting short, invisible radiant energy waves into longer wave lengths of visible light.

fluoride—A compound of fluorine with another element or radical.

fluoroscopy—Examination of an object by projecting the X-Ray shadow on a fluorescent screen.

flush—In the same plane; straight.

fluted—Channeled; grooved.

fortuitous—Happening by chance or accident.

fresco—The art or method of painting on freshly spread plaster before it dries.

fresnel—A special type of lens designed by a man named Fresnel, to refract light from a searchlight on a narrow parallel beam.

friction—The act of rubbing one body against another—a resistance to motion between two surfaces in contact.

frieze—Any sculptured or richly ornamented band in a building.

fuse—To be blended—to melt.

gasket—A line or band used for packing pistons, making pipe joints, etc., to make them leak-proof.

gelatinous—Resembling jelly.

generic—Characteristic of natural groups rather than individuals.

geologic—Pertaining to geology which is a study of the history of the earth and its life.

germicide—Sterilizing.

glacier period—An era in the geologic history of the world.

glare—Any sharp, intense contrast of light.

glass—An amorphous substance, usually transparent or translucent, consisting ordinarily of a mixture of silicates, but in some cases of borates, phosphates, etc.

glazing—Act of furnishing or fitting with glass.

gold leaf—Very thin gold foil used for gilding, etc.

granular—Having a structure or texture consisting of grains or granules.

grinding—Removal of material from a mass by crushing an abrasive material against the mass.

grout—Thin mortar used for filling in the joints in masonry.

heterogeneous—A mixture of several unlike substances—not uniform.

hexagonal—Having six sides and six angles.

hoist—A lifting apparatus.

homogeneous—Uniform in structure, composition, etc.

hopper—A box-like container from which the contents may be fed at will.

humidity—Moisture; dampness; water-vapor content of the air.

hydrofluoric—Pertaining to or designating an acid compound of hydrogen and fluorine.

hydrostatic—Pertaining to the pressure and equilibrium of fluids.

hygroscopic—Readily absorbing and retaining moisture.

hypodermic syringe—A small syringe with a hollow needle-like point, used to inject medicine, etc., beneath the skin.

illumination—A supplying with light.

impervious—Not admitting of entrance or passage through.

impinge—To thrust; collide with.

impregnated—Completely filled with.

incandescent—Clear, shining, brilliant.

increment—Growth in bulk, increase.

inculcate—To instill; impress.

incurve—A bending or curving inwards, concave.

inert—Indisposed to move or act, passive, sluggish.

infra-red—Pertaining to that part of the spectrum lying outside of the visible spectrum at its red end.

insulation—Separation from conducting bodies by means of non-conductors.

intaglio—An engraving or incised figure in stone, glass or other hard material.

interlayer—A layer inserted between.

interleave—To insert leaves between.

intermittent—Alternating; periodic.

iridescent—Having colors like the rainbow, changeable in appearance depending upon the angle of view.

jobbing—Acting as a middleman between producers and those who sell to the public.

kiln—A furnace of brick or stone.

knurled—A design cut or stamped into a surface usually by a knurling tool—spaced grooves cut into a surface at an angle to each other.

lacquer—Varnish.

lag screws—Screws having a wide pitch thread used for fastening equipment to a floor, beam, etc.

lamine—To assemble separate layers into a unit.

letting—Closing a contract with the successful bidder.

light—Pane of glass.

lintel—A horizontal member spanning an opening to carry a superstructure.

litharge—Fused lead oxide, usually ground to a fine powder.

lock housings—The casings which enclose a lock.

lubricant—A substance such as oil interposed between moving parts of machinery to reduce friction.

luminaire—A light or lamp.

luminescent—Pertaining to any emission of light not ascribable directly to incandescence, occurring at low temperatures.

mannikin—Dressmaker's model.

masking—A covering to prevent damage.

mastic—Pasty cements, as those made by boiling tar with lime, powdered brick, or the like.

matrix—The fundamental material in which others are included as unassimilated suspended particles.

miter—The surface forming the beveled end or edge of a piece where a miter joint is made.

modulus—The measurement of force which must be applied in order to produce rupture.

monel—A native alloy of nickel and copper found principally in the neighborhood of Sudbury, Ontario, Canada.

monochromatic—Having or consisting of one color.

monolithic—Hewn from solid rock—usually a concrete structure is called monolithic.

monorail—A single rail serving as a track.

mullion—A slender bar or pier forming a division between lights of windows, etc.

munтин—Transverse stays securing longitudinal beams.

murіatic—Pertaining to hydrochloric acid.

natron—Native sodium carbonate.

nepheline syenite—A granitoid rock consisting of nephelite and orthoclase and other minerals.

oakum—The material obtained by untwisting and picking into loose fiber old hemp ropes.

obsidian—Volcanic glass of a solid compact structure.

opacifier—Rendering impervious to the rays of light.

opalescence—Reflection of an iridescent light.

opaque—Impervious to the rays of light.

ophthalmic—Glass intended for use as spectacles.

optic—Relating to vision.

optimum—The most favorable degree, quantity, etc.

orifice—Opening; aperture.

parabolic—Relating to a plane curve or surface any point of which is equidistant from a fixed point and a fixed straight line, all three points laying in the same plane.

pendant—The sculptured lower end of a piece of the framing of a roof, stair, or ceiling. A hanging ornament or tassel.

pH—Hydrogen ion concentration—Acid reaction is $pH < 7$. Alkaline reaction is $pH > 7$. $pH = 7$ is neutral.
($<$ Means less than.) ($>$ Means more than.)

phosphorescent—Luminous without sensible heat.

pilaster—A pillarlike or cylindrical form or shape.

pinion—A small gear usually used to drive a much larger gear.

pitch—A slope or degree of slope; point or peak—

the distance from the crest of one wave to the crest of its neighbor.

plumb—A weight attached to a line for the purpose of indicating a vertical direction, hence vertical.

polarization—Briefly, the splitting of a beam of light into two components, each vibrating in its own plane.

pot colored—The homogeneous color developed in glass melted in a pot; in other words, a solid color.

precipitation—A chemical term meaning that one material is thrown out of solution by the addition of another material.

prismatic—Pertaining to a solid whose bases or ends are similar, equal, and parallel polygons, the faces being parallelograms.

pulverize—To reduce to a fine powder or dust.

pumice—A hardened volcanic glass froth used for smoothing and polishing.

punty—An iron tube or rod used for manipulating the hot glass—a tube used to gather glass which is to be blown to shape.

pyroxylin—Cellulose nitrate plasticized with camphor and various other substances, and cured.

quarries—Open excavations for obtaining stone, slate, or limestone and other minerals.

quiescent—Being in a state of repose.

rabbet—A longitudinal channel open on two sides, cut out of the edge or face of a body.

radiant energy—Energy emitted or transmitted by radiation.

radiate—Disseminate, especially radiant energy, as light and heat from the sun or radio waves from a broadcasting station.

radius—A straight line extending from the center of a circle or sphere to the curve or surface.

ramification—All of the contacts and effects.

range finder—An instrument, variously constructed, used to determine the distance of an object to be hit.

ream—Inclusions within the glass of layers, cords or strings of glass not homogeneous with the main body of glass.

rectilinear—Formed or bounded by straight lines.

reducing agent—A substance that will change the state of oxidation of a chemical to a relatively lower state of oxidation.

re-entrant—Directed inwards, as an angle.

reflector—A polished surface or body for reflecting light or heat, as a mirror.

refractory—Resisting ordinary treatment; difficult to fuse.

regenerative—The method of absorbing in checker-work the heat from combustion gases, and thereby preheating the incoming air necessary for combustion on the reverse cycle.

reradiated—To absorb radiant or sensible energy and again radiate it.

research—Careful or critical examination in seeking facts.

residue—Remainder; remnant.

resilient—Returning to, or resuming, the original position or shape.

retort—Usually a vessel in the shape of a bulb of glass with a curved beak; part of the equipment in chemical laboratories—a flask or container for a chemical reaction.

retract—Withdraw.

reveal—The side of an opening for a window, etc., between the frame and the outer surface of the wall; the jamb.

rose metal—A special eutectic mixture of Bismuth, Tin and Lead which exhibits the property of expanding as it cools from the molten to the solid state.

run—The over-all production just as it emerges from the tank or the production line—without selection.

rupture—Break, disruption.

salamander—A metal container for fire, having open grillwork sides and bottom, brazier.

sash—The framing in which panes of glass are set in a glazed window or door, including the narrow bars between panes.

score—Mark with lines, scratches, notches.

scourge—Trial and tribulation.

seam, to—Grind off the edge of the face of a plate of glass at a narrow angle.

seed—A small bubble in the glass, less than $\frac{1}{32}$ " diameter.

serrated—Notched or toothed on the edge like a saw.

setting accelerators—A material designed to make a mortar set up more quickly than it would if the accelerator were not present—old mortar or plaster in a fresh mix will often act as an accelerator.

shawl—A half cylinder of window glass.

short finish—Incompletely polished glass.

siege—The floor of a glass furnace, upon which the pots rest.

skewback—A special clay block, trapezoidal in shape, against which are supported the extremes of the crown of a furnace.

ships—Movable buckets or hoppers standing on legs.

solubility—Capability of being dissolved.

solvent—A substance having the power of dissolving.

spall—To chip along the edges.

spandrel—The space from the top of the window to the sill of the window in the story above.

spar—A beam or rafter.

spawn—To spread.

specular—Having a smooth, reflecting surface—not polarized.

spewing—The pouring forth of material through an opening.

spheroid—A figure like a sphere, but not spherical.

stearate—A salt of stearic acid.

stellite—An alloy of Chromium, Cobalt, Molybdenum and Tungsten—the hardness depends upon the relative amount of Tungsten—can only be cast and ground, cannot be machined. (Molybdenum and Tungsten are both chemical, metallic elements, not mentioned in Section A-3.)

stile—The principal piece in wainscoting.

stippled—Engraved by means of dots—uneven, small touches, splotchy.

stone—Unassimilated partially melted particle of rock, clay or batch material imbedded in the glass.

stress—Pressure; strain.

subsidiary—Assistant; auxiliary.

symmetry—Correspondence or similarity of form; harmonious balance.

synchronize—To cause to agree in time, or timing.

systematize—To arrange methodically.

tailing—The residue of molten glass remaining in the pot—or wasted from it—when the cast is complete.

temper—To bring to a proper degree of hardness and toughness.

template—A thin plate or board cut to the desired shape and used as a guide in producing duplicates. A pattern.

tensile strength—The resistance of a material to breakage under the stress of pulling or stretching.

tension—The act of stretching, straining or tensing.

terrazzo—A kind of cement flooring including fragments of colored stone, commonly not set in patterns.

thermal—Pertaining to heat.

thermo-plastic—A material which readily may be changed in shape under the combined effects of heat and pressure.

tidal—With the ocean tides.

tie rod—A rod used to hold the buckstays of a furnace from spreading apart, to keep the skewbacks of the crown of a furnace in place, against the expansion of the crown under heat.

tolerance—Allowed amount of variation from the standard or specified dimensions.

traction—The adhesive friction of a body on a surface over which it moves.

translucent—Permitting light to pass freely, but so scattered that objects cannot be distinguished through the translucent material.

transparent—Permitting light to pass freely, without scattering, so that bodies can be distinctly seen through the transparent material.

tuille—Door to a pot furnace.

utilitarian—Aiming at practical usefulness as distinguished from beauty, ornament, etc. Functional.

vagary—Wandering of thought; a whim.

variegated—Having marks or patches of different colors.

velocity—Quickness of motion.

versatility—Quality of being many-sided; facility in various subjects; availability for many uses.

vignetting—The shading off gradually into the surrounding ground, or unprinted paper.

viscosity—Resistance to flow, of a material, particularly a liquid or molten material.

viscous—Strongly resistant to flow.

volatile—Easily wasting away by evaporation.

wainscot—The paneled lining of an interior wall.

weep hole—A hole in a retaining wall to drain off liquids.

wheel-cut—A cut in glass made by a revolving wheel.

white wheel—A wood or cork faced wheel upon which pumice is used as the medium for polishing glass.

white-wheelers—Men who finish glass on the white wheel.

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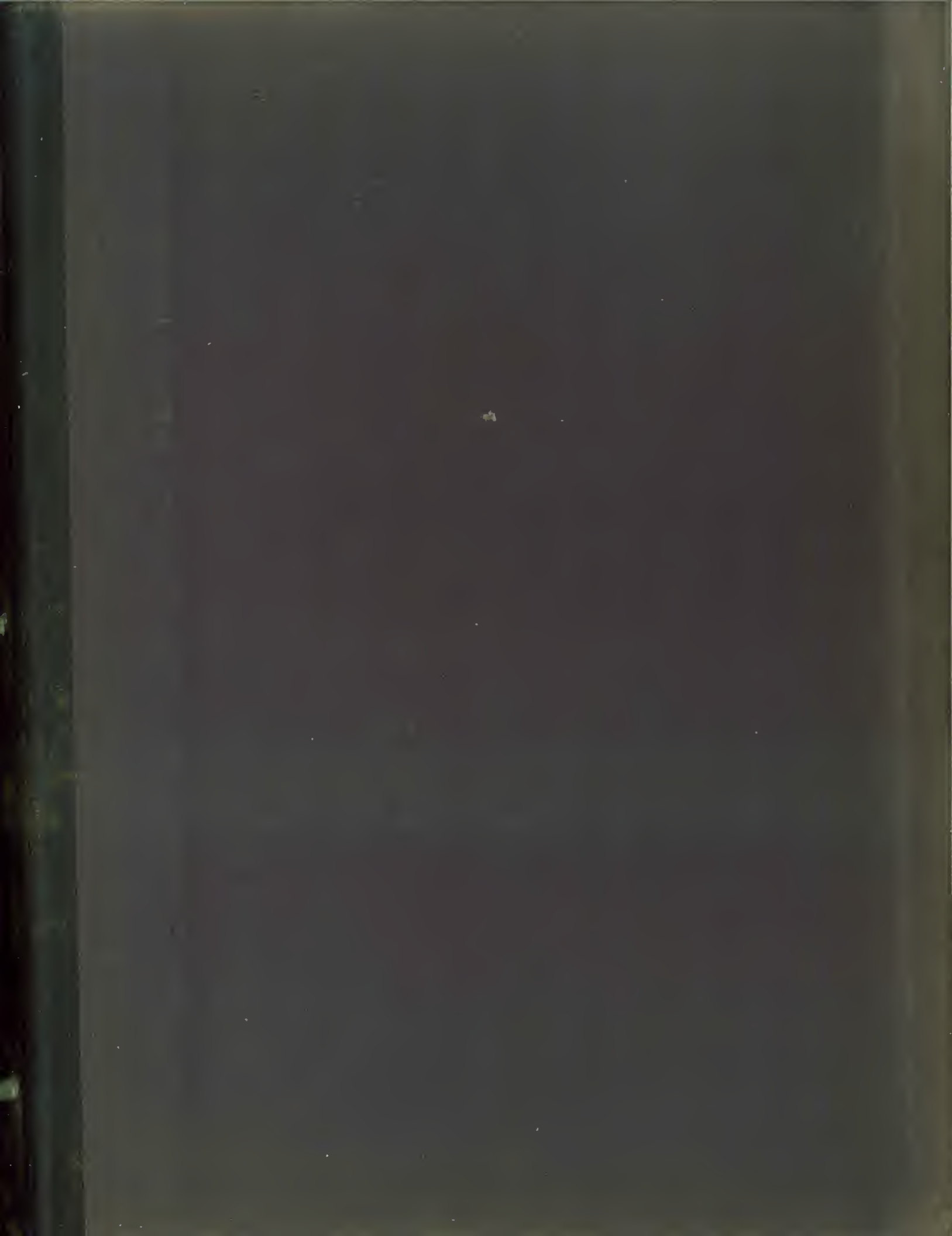
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